

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

HESAI TECHNOLOGY CO., LTD.
Petitioner

v.

OUSTER, INC.
Patent Owner

Case No. IPR2023-01456
U.S. Patent No. 11,178,381

PATENT OWNER RESPONSE UNDER 37 C.F.R. § 42.120

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<i>Transocean Offshore Deepwater Drilling, Inc. v. Maersk Drilling U.S., Inc.</i> , 699 F.3d 1340 (Fed. Cir. 2012)	61
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EXHIBIT LIST

EXH. NO.	DESCRIPTION
2001	Respondent's Proposed List of Terms to be Construed dated June 21, 2023, in ITC Inv. No. 337-TA-1363
2002	Respondent's Proposed Claim Constructions dated June 28, 2023, in ITC Inv. No. 337-TA-1363
2003	Respondent's Proposed List of <i>Markman</i> Exhibits dated July 13, 2023, in ITC Inv. No. 337-TA-1363
2004	Excerpts from Rudolf F. Graf, <i>Modern Dictionary of Electronics</i> (7th ed. 1999)
2005	Excerpts from Frank Pedrotti, <i>Introduction to Optics</i> (3d ed. 2006)
2006	Excerpts from Ulrich Kubitscheck, <i>Fluorescence Microscopy, From Principles to Biological Applications</i> (2d ed. 2017)
2007	Biography of Patrick W. Lauppe
2008	Declaration of Patrick W. Lauppe ISO Motion for <i>Pro Hac Vice</i> Admission
2009	Declaration of Jason Janét, Ph.D.
2010	Transcript of James F. Shanley, Ph.D., deposition dated June 28, 2024
2011	The Oxford English Dictionary (2d Ed., Vol. III), Cham-Creeky (1989) (excerpts)
2012	Sergey L. Vinogradov, "Evaluation of performance of silicon photomultipliers in LIDAR applications" (2017)
2013	Edoardo Charbon et al, "SPAD-Based Sensors" (2013)

EXH. NO.	DESCRIPTION
2014	Cristiano Niclass, et al, “A Single Photon Avalanche Diode Array Fabricated in Deep-Submicron CMOS Technology” (2006)
2015	Transcript of James F. Shanley, Ph.D., deposition dated June 6, 2024
2016	Transcript of Michael Lebby, Ph.D., deposition dated May 23, 2024 (excerpts)
2017	Hesai Technology Co., Ltd.’s Petition in IPR2023-01422, dated September 14, 2023

The Board should find claims 1-3, 5-8, and 10-17 (the “challenged claims”) of U.S. Patent No. 11,178,381 (the “’381 patent”) patentable over the instituted grounds.

I. INTRODUCTION

The ’381 patent represents another example of Ouster’s innovative approach to LIDAR that has transformed the industry and led to the widespread success and adoption of Ouster’s sensors and technology. Like other patents challenged by Petitioner, Ouster’s ’381 patent relies on emitters and sensors previously disfavored in the industry for high-noise, demanding LIDAR applications. These include the relatively lower power (and hence, weaker signal) VCSEL laser emitters and the sensitive but unreliable and noisy single-photon avalanche diode (“SPAD”) sensors. To build a system with these components, the Ouster inventors had to develop new optical systems, including specific configurations of optical elements to overcome the challenges of using VCSELs and SPADs. The result of Ouster’s innovations was cheap, efficient, and highly sensitive LIDAR devices. Using the hindsight of a LIDAR industry shaped by Ouster’s own contributions, Hesai now attacks the ’381 patent by advancing unsupportable claim interpretations and manufacturing details in vague disclosures in the asserted prior art. Petitioner’s obviousness grounds must fail—the Board should find the challenged claims of the ’381 patent patentable over the instituted grounds.

etitioner's challenges fail for multiple reasons. *First*, each of the grounds fails because the proposed combinations do not satisfy the claim limitations "each pixel in the plurality of pixels has a field of view coincident with an emission region of [a corresponding/its paired] optical emitter." Properly construed, these limitations mean that the field of view of each pixel and the emission region of a corresponding [or paired] optical emitter cover substantially the same area in the field. Dr. Shanley's opinions rely upon the misapplication of the term to only take into account the *direction* of the emission regions and fields of view—not the *area* of these regions. Applying the correct interpretation of "coincident with" to the asserted prior art, Retterath (all Ground 1 combinations) and Imai (all Ground 2 combinations) fail to disclose emission regions of emitters that cover substantially the same area in the field as the field of view of their corresponding or paired pixels.

Second, each of the grounds fails as to claim 1 and its dependents because the proposed combinations do not satisfy the claim limitation "a bulk imaging optic disposed adjacent to the bulk transmitting optic." In the Retterath combinations (Grounds 1A-G), Dr. Shanley relies on an embodiment associated with a *single* lens that is used for both the emitter (transmitting) and detector (imaging) and then asserts with no analysis that a POSITA would have imported optics from other embodiments to construct a system with *two* separate optics adjacent to one another. In the Imai combination (Grounds 2A-C), Dr. Shanley admitted in deposition that

the disclosures related to an embodiment from the Imai reference he relies upon omit “a lot” and provide “just a sketch” of the system—failing to disclose details about the spatial relationship of the optics with respect to one another.

Third, Petitioner attempts to combine references that are clearly incompatible with each other. For example, without support, Petitioner seeks to take single-photon avalanche diodes (SPADs)—which Petitioner’s expert concedes are “particularly problematic” with regard to interference and noise—and combine them in a system with a “shadow mask” that causes noise and interference based on reflections it generates in an optical system.

Fourth, for several dependent claims, Petitioner’s grounds are clearly off-base. For claim 3, Petitioner argues that “proportional . . . arrangement[s]” of emitters and detectors are disclosed in the art by pointing to emitter and detector arrays that have the same *number* of elements. Since an equal *number* does not indicate a proportional *arrangement*, Petitioner’s grounds must fail as to claim 3. Petitioner also tries to assert that dependent claim 7, which requires an “opaque” structure, is satisfied by a semi-transparent layer in the prior art. Multiple dependent claims must survive in light of Petitioner’s facially incorrect reads.

Similar to Petitioner’s other challenges of Patent Owner’s patents, the inadequacy of Petitioner and its expert’s obviousness combinations is confirmed by clear evidence in support of secondary considerations of nonobviousness. For

example, Hesai's expert's testimony confirms the skepticism of the industry toward SPAD-based approaches to LIDAR represented by the '381 patent claims. Hesai's expert testified that though he was aware of SPADs as early as the 1990s, he never used SPADs in any of the various LIDAR systems he subsequently worked on because of concerns about their volume, power requirements, reliability, complexity, lack of availability, and difficulty of use—including their incompatibility with large swaths of the electromagnetic spectrum. Further, Hesai's expert could not identify a single LIDAR system—commercial or otherwise—prior to the '381 patent that used SPADs. In addition to industry skepticism, there is clear evidence of the failure of others in support of the nonobviousness of the '381 patent claims. Publications from around and after the priority date of the '381 patent indicate that many had tried but all had failed to develop workable SPAD arrays for a LIDAR system prior to the '381 patent.

II. BACKGROUND

A. Level of Ordinary Skill in the Art

Patent Owner submits that a POSITA would have had an undergraduate degree in mechanical or electrical engineering and two to three years of work experience with electro-optical and electro-mechanical devices or systems, with, at a minimum, at least one year of work experience was with LIDAR designs, where less work experience may be compensated by a higher level of education or vice versa. (EX2009, ¶60.)

Petitioner asserts that a POSITA would have had more years in LIDAR design. (Pet. at 3.) These additional requirements on a POSITA's level of experience appear to be Petitioner and its expert's attempt to shore up the incompatible obviousness combinations on which the petition relies, as outlined below. Indeed, Petitioner's position on the level of ordinary skill seems to be determined solely by litigation exigencies. In Petitioner's co-pending attack on Patent Owner's U.S. Patent No. 11,287,515 (IPR2023-01422), Petitioner relies upon an expert with minimal LIDAR experience. (EX2016, 9:19-10:10.) Unsurprisingly, Petitioner's POSITA definition in that proceeding includes *no* LIDAR experience. (EX2017 (IPR2023-1422 IPR Petition) at 9.) But here, Petitioner's definition is different—requiring “2-3 years of experience in LiDAR design.” (Pet. at 3.) In contrast to Petitioner's changing and apparently litigation-driven POSITA definition, Patent Owner has consistently proposed one consistent POSITA definition across its responses to Petitioner's various challenges that matches the reality of the industry. (EX2009, ¶62.) Accordingly, Patent Owner submits that Patent Owner's POSITA definition should be adopted.

B. Specification Overview

U.S. Patent No. 11,178,381 B2 (the “'381 patent”), titled “Optical System for Collecting Distance Information Within a Field,” was filed on May 18, 2021, granted November 16, 2021, and claims priority to provisional application No. 62/232,222,

filed on September 24, 2015.

An embodiment of the '381 patent's system is shown in Figure 1:

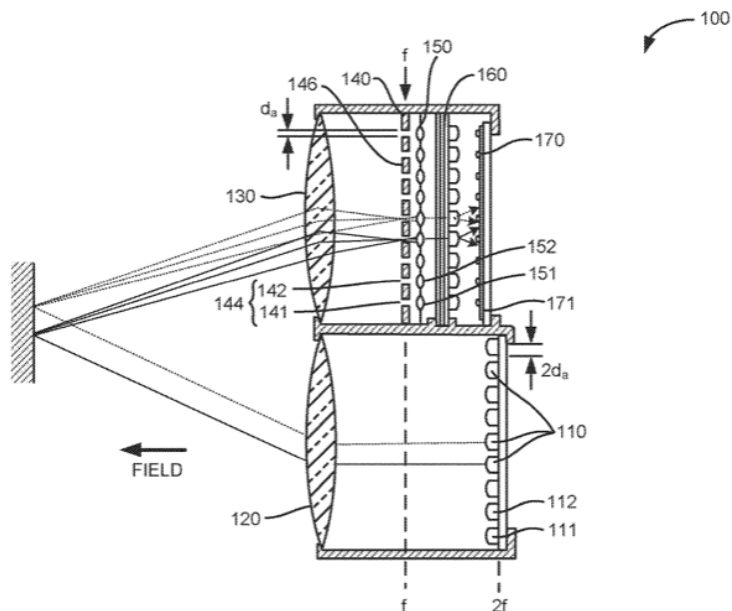


FIG. 1

(EX1001, FIG. 1.) Illumination sources **110** “output an illuminating beam . . . toward a discrete spot in the field ahead of the illumination source” through bulk transmitting optic **120**. (*Id.*, 2:7-11.) Light is deflected from the field back into the detection system, which includes bulk imaging optic **130**, aperture layer **140**, lenses **150**, optical filter **160**, diffusers **180**, and pixels **170**, which detect the deflected light. (*Id.*, 2:11-38.)

The '381 patent discloses emitting light in an “illumination pattern that substantially matches—in size and geometry across a range of distances from the system—the fields of view of the apertures.” (EX1001, 2:67-3:4.) As a result,

“minimal power output by the system (via the illumination sources) is wasted by illuminating surfaces in the field for which the pixels are blind” so the system can “achieve a relatively high ratio of output signal (i.e., illuminating beam power) to input signal (i.e., photons passed to an incident on the pixel array).” (*Id.*, 3:4-10.)

The '381 patent discloses embodiments where the set of pixels **170** “includes an array of single-photon avalanche diode detectors” or “SPADs.” (EX1001, 9:7-13.) Further, the '381 patent discloses using vertical-cavity surface-emitting laser (VCSEL) arrays as the emitters. (*Id.*, 11:6-13.)

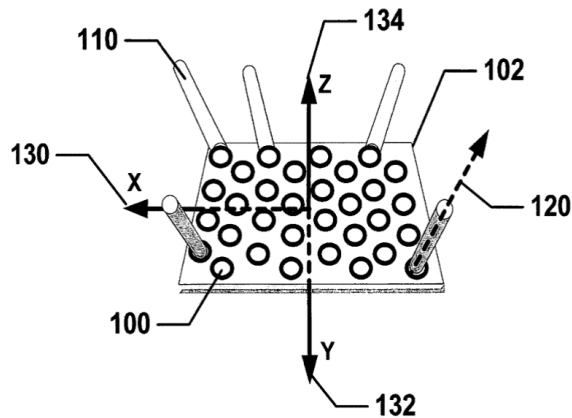
III. PETITIONER’S ASSERTED PRIOR ART

A. Retterath

U.S. Patent No. 10,203,399 B2 (“Retterath”) is a patent that discloses “LiDAR (light detection and ranging) systems” that “use an array of emitter/detector sets.” (EX1005, 2:66-3:5.) Retterath does not specify what types of emitters and detectors are used in its system. (*See, e.g., id.*, 6:57-59.)

Figure 4 of Retterath shows an array of emitters **100** that each emit a beam **110** with vector **120**:

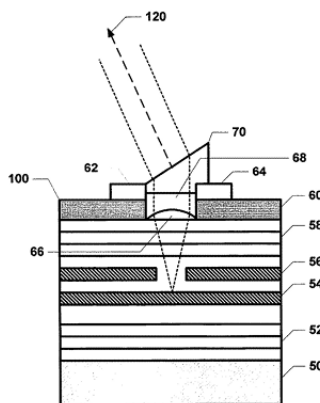
Figure 4



(EX1005, FIG. 4.)

Figure 5a of Retterath shows “an emitter of emitter elements 100” where “[a] directional lens 70 directs the collimated beam of light 68 along a desired emitter vector 120.” (EX1005, 8:20-50.)

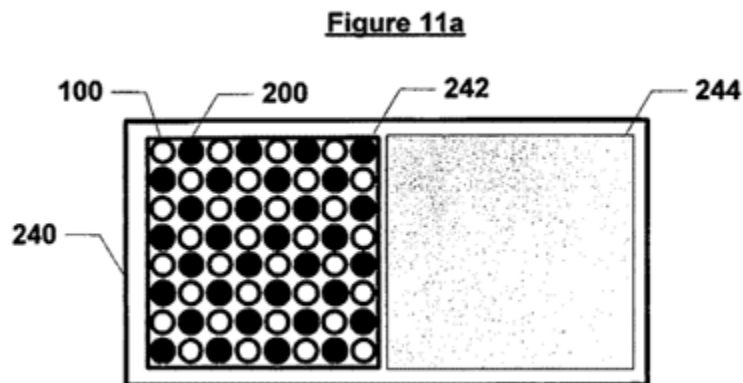
Figure 5a



(*Id.*, FIG. 5a.)

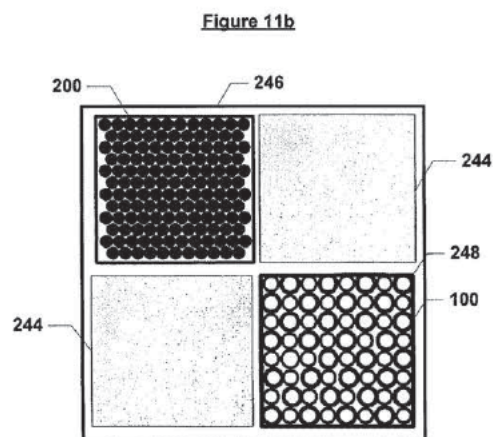
Retterath further discloses that a “single global lens can be used for emitter elements **100** and detector elements **200**. (EX1005, 10:50-51, 11:10-15 (“global lens

detectors”).)



(*Id.*, FIG. 11a.)

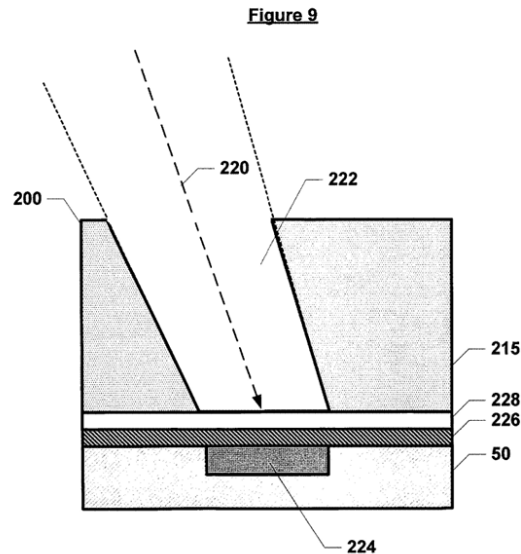
Figure 11b of Retterath shows emitter elements 100 (shown in an even grid) and detector elements 200 (shown in a staggered grid) that are disposed in different arrangements where the number of detectors 200 can be greater than or equal to the number of emitters 100. (EX1005, 10:61-11:4.)



(*Id.*, FIG. 11b.)

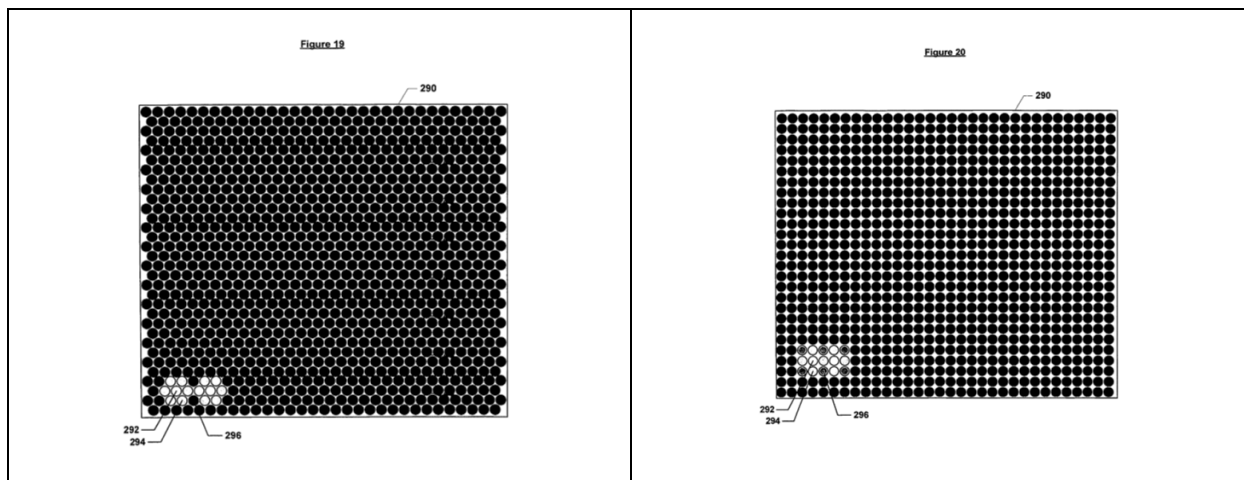
Figure 9 of Retterath shows “a cross section of a side view of a detector

of detector elements **200** element fabricated with an angular waveguide[,]” where the waveguide material 215 is a material that is “substantially non-reflective” and that “partially reduces[s] in intensity” or “substantially” blocks light. (EX1005, 10:4-6, 10:14-17, 9:56-65.)



(*Id.*, FIG. 9.)

Retterath discloses that the emitter/detector sets are on “a common on-coincident axis[,]” the angle of which “is unique for that emitter/detector set.” (EX1005, 6:23-39.) Retterath discloses embodiments with “a plurality of detector elements for each emitter element” and a smaller light beam to reduce cross talk. (*Id.*, 17:43-46, 9:36-44, 11:33-37, Figs. 19-20, 17:58-60 (“secondary detectors”), 18:29-32 (“tertiary detectors”).)



(*Id.*, FIGS. 19 and 20.)

B. Borowski

U.S. Patent Application Publication No. US 2013/0300838 A1 (“Borowski”) discloses a 3D landscape real-time imager using “an ultra-short laser pulse source” and a set of SPAD detector arrays. (EX1006, Abstract, [0001].)

Borowski discloses that its device is faster than conventional techniques, in part because the disclosed device “offers an improved trade-off between image depth resolution and fast data acquisition for the detection of movements.” (EX1006, [0003], [0044] (proposing the use of “multiple SPADs”).)

Figure 1 of Borowski shows “four SPAD sensor cells **3-6** built on the same first CMOS IC 1.” (EX1006, [0154].)

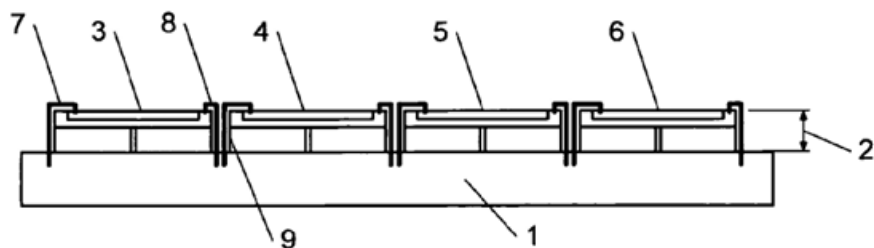


Fig. 1

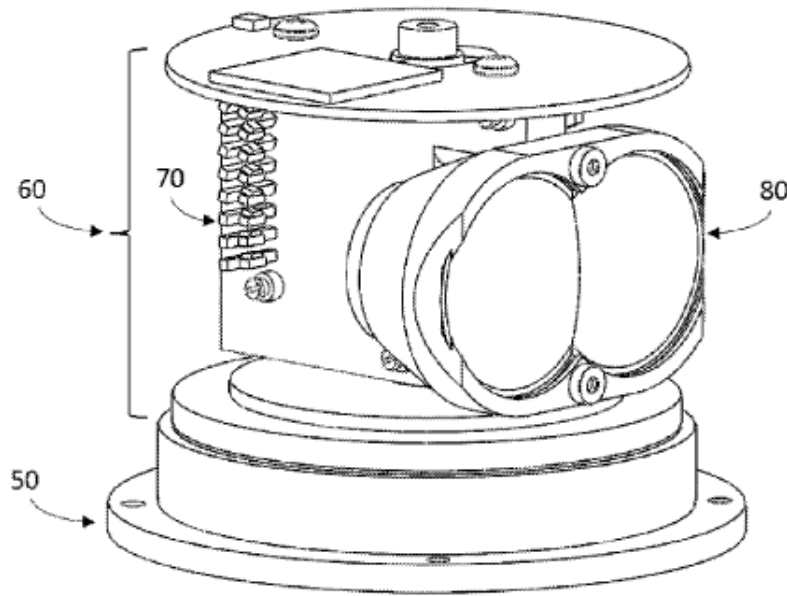
(*Id.*, FIG. 1.)

Borowski discloses that the SPADs can be disposed in “a 4-SPAD sensor cell **92** of the SPAD sensor array.” (EX1006, [0233]-[0234], FIG. 12.)

C. Pacala

U.S. Patent Publication No. 2014/0211194 A1 (“Pacala”; EX1013) is a high-level description of a rotating LIDAR sensor that “contains a motor and distributed electronics, and a spinning turret **60** that contains optoelectronic component **70** (including optical transmitters and receivers), collimation and focusing lenses **80** and distributed electronics.” (*Id.*, [0013].) Pacala was abandoned during prosecution.

The sensor is shown in Pacala’s Figure 2:



(EX1013, Fig. 2.) Most of the remaining description of Pacala is dedicated to discussing signal processing circuits, with the final sentence stating: “The multi-channel TDC electronic circuitry with multiple voltage thresholds can be implemented with discrete integrated circuits (ICs), in the form of FPGA logic, as part of an application-specific integrated circuit (ASIC), or integrated into the pixels of a detector array (e.g., Single-Photon Avalanche Diode [SPAD] array).” (*Id.*, [0014].)

D. Hipp

U.S. Patent No. 7,787,105 B2 (“Hipp”) is a patent that discloses “[a] system and method for [] taking . . . distance images[,]” using an array of transmitters 115 and an array of receivers 8. (EX1007, Abstract, 1:27-37, FIGS. 3, 6, 11:63-12:4, 12:16-29.)

Hipp further discloses using a reflective “mirror coated” shadow mask

“printed onto the cover plate of the APD array or onto an APD.” (EX1007, 21:57-67, FIG. 16.) Hipp discloses noise and interference issues associated with its shadow mask:

[S]ome of the light which passes through the holes of the shadow mask could be reflected by the APD and be reflected back from the lower side of the shadow mask and also still be scattered under certain circumstances. After approximately a two-fold reflection to and fro, this light would be able to reach the adjacent active zones and act as an interference signal there.

(*Id.*, 22:1-7.)

E. Weimer

U.S. Patent No. 8,736,818 B2 (“Weimer”) is a patent that discloses “electronically steered flash LIDAR systems and methods in which illumination within a scene is adaptively controlled[.]” (EX1008, 1:5-9.)

Figure 3A shows a flash LIDAR system for use in a spacecraft 108.

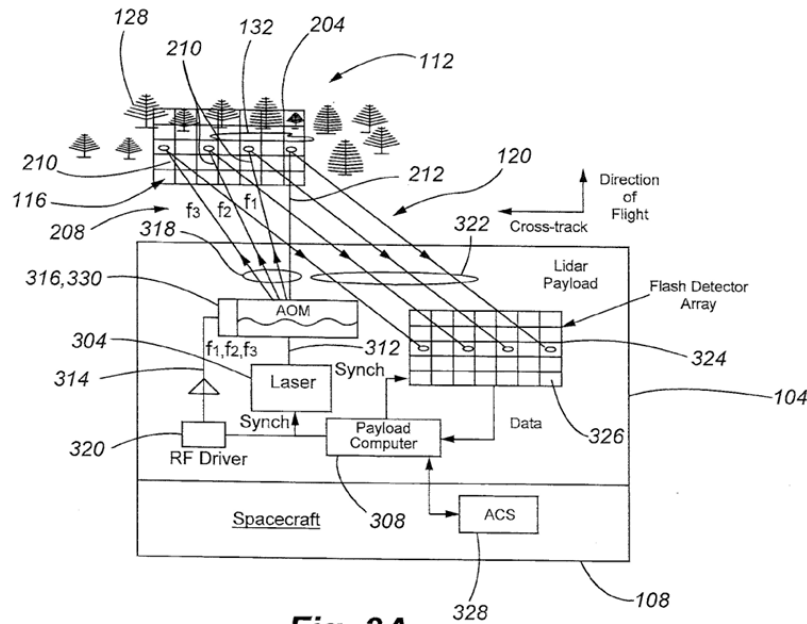


Fig. 3A

(*Id.*, FIG. 3A, 8:48-10:45.)

Weimer also discloses that large fields of view are not desirable due to an increase in background light and suggests using a laser with a smaller spot size than the receivers' field of view. (EX1008, 1:53-59.)

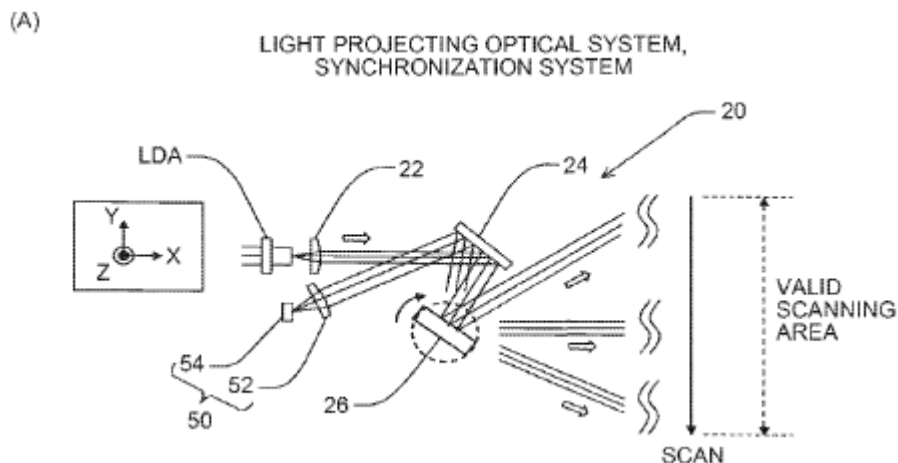
F. Imai

U.S. Patent Application Publication No. 2016/0274223 A1 (“Imai”) discloses an “object detecting device.” (EX1009, [0008].) Petitioner relies on Japanese Application No. JP2015-055314 in support of the alleged priority of Imai over the ’381 patent.

Imai discloses “a scanning laser radar . . . for detecting whether there is an object . . . by emitting light and detecting a distance to the object[.]” (EX1009, [0027].) The laser radar 100 is a laser diode array made up of a plurality of laser

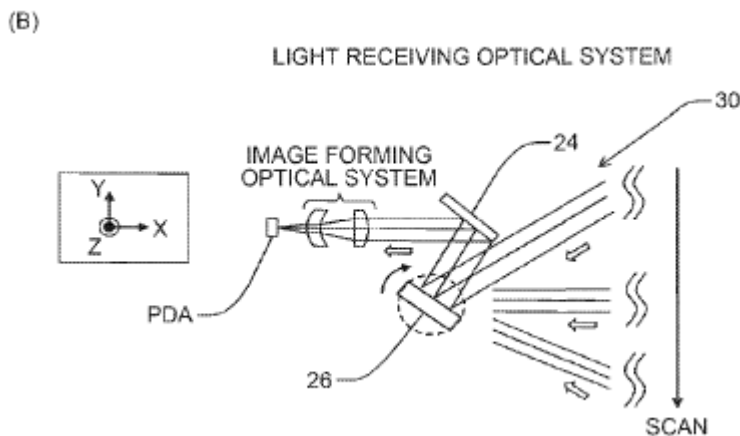
diodes and other components as illustrated in Fig. 1. (*Id.*, [0029].)

Figure 2A of Imai shows a “light *projecting* optical system 20 and the synchronization system 50” that includes a coupling lens 22, a reflecting mirror 24, and a rotary mirror 26. (EX1009, [0031]-[0032] (emphasis added).)



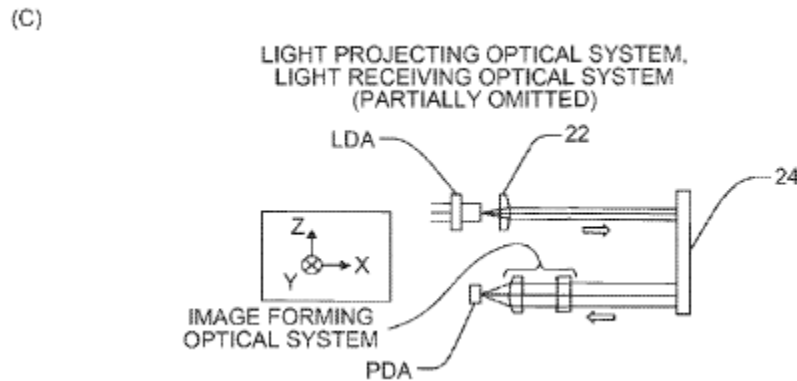
(*Id.*, FIG. 2A.)

Figure 2B of Imai shows a “light *receiving* optical system 30” that includes a rotary mirror 26 and a reflecting mirror 24 for reflecting the received light onto the photo diode array. (EX1009, [0031], [0037] (emphasis added).)



(*Id.*, FIG. 2(B).)

Figure 2C of Imai shows “the optical path from the LDA to the reflecting mirror **24** and the optical path from the reflecting mirror **24** to the PDA are illustrated in a partially omitted manner.” (EX1009, [0038], FIG. 2(C).)

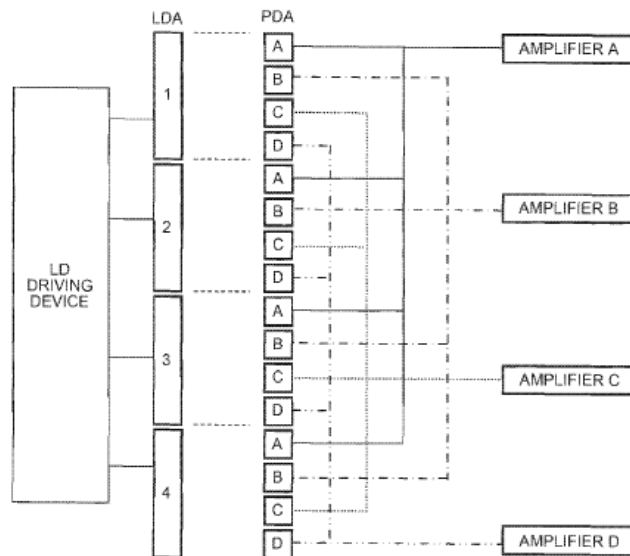


(*Id.*, FIG. 2C.)

Figure 10 of Imai shows a PDA and LDA that are both arranged vertically and where there are four times as many PDs (photo diodes) as LDs (laser diodes). (EX1009, [0097]-[0098], FIG. 10.) “The irradiation range of each LD is set to be slightly larger than corresponding light receiving ranges of the four PDs.” (*Id.*, [0101].)

FIG.10

FIRST MODIFICATION

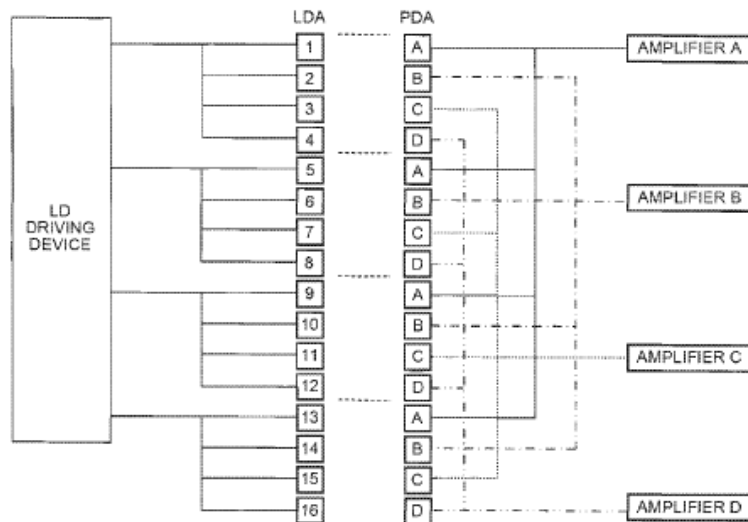


(*Id.*, FIG. 10.)

Imai also discloses another embodiment closely related to the Figure 10 embodiment, which is shown in Figure 11:

FIG.11

SECOND MODIFICATION



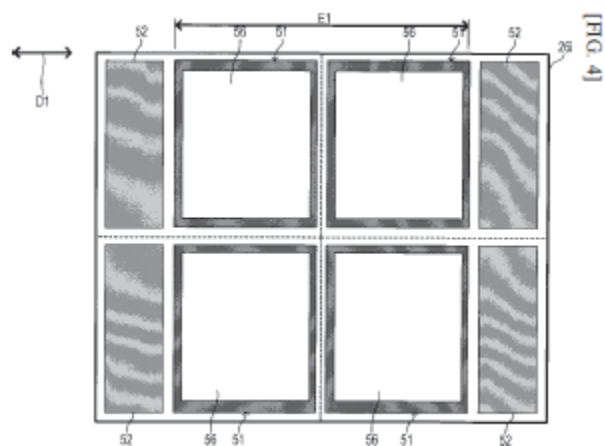
(EX1009, FIG. 11.) In this embodiment the number of LDAs and PDAs is the same.

(*Id.*, [0125].)

G. Higashi

Japanese Publication No. 2015-078953 (“Higashi”) is a publication that discloses “[a] radar device 1 [that] is mounted in a vehicle and [that] comprises of a light source 2, a one-dimensional scanner 3, a scanning control unit 4, a light detection unit 5 and a processing unit 6.” (EX1011, [0015], FIG. 1.)

Figure 4 of Higashi shows a pixel 26 that is made up of four single photon avalanche diodes (SPADs). (EX1011, [0027], FIG. 4.)

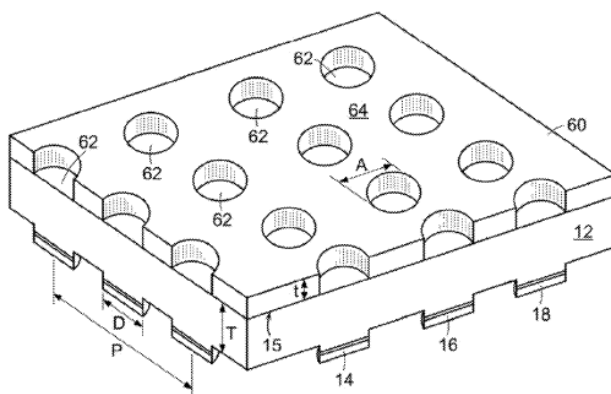


(*Id.*, FIG. 4.)

H. Grzesik

U.S. Patent Application Publication No. US 2017/0040368 A1 (“Grzesik”) is a patent application that discloses “photodiodes that can generate light in the manner of avalanche photodiodes such as Geiger-mode avalanche photodiodes.” (EX1012, [0002].)

Figure 3 of Grzesik shows “a schematic view of a cross talk absorber layer that can be provided on a photodiode array substrate”:



(EX1012, FIG. 3, [0012].)

Figure 4 of Grzesik shows “a cross-sectional side view of the photodiode array of FIG. 1 here including the cross talk absorber layer **60**”:

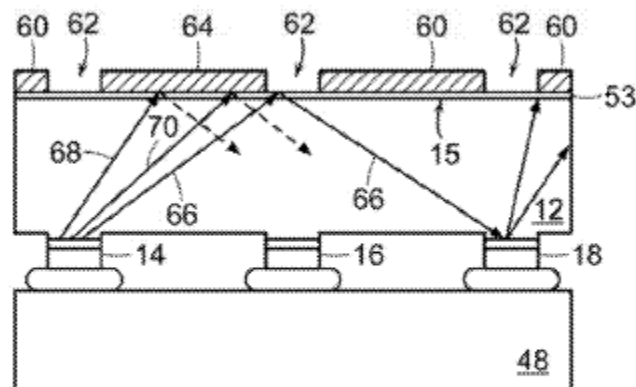


FIG. 4

(EX1012, FIG. 4; [0035].) Grzesik discloses a “cross talk absorption layer **60**” that at least partially suppresses light. (*Id.*, [0034].)

IV. THE BOARD SHOULD REJECT PETITIONER’S PROPOSED COMBINATIONS.

A. The Board Should Reject the Retterath-Based Grounds

Petitioner characterizes each of Grounds 1A-1G as relying on Retterath for a LIDAR system and relies on Borowski for alleged disclosures of “SPAD detector arrays.” (Pet. at 12-15.)

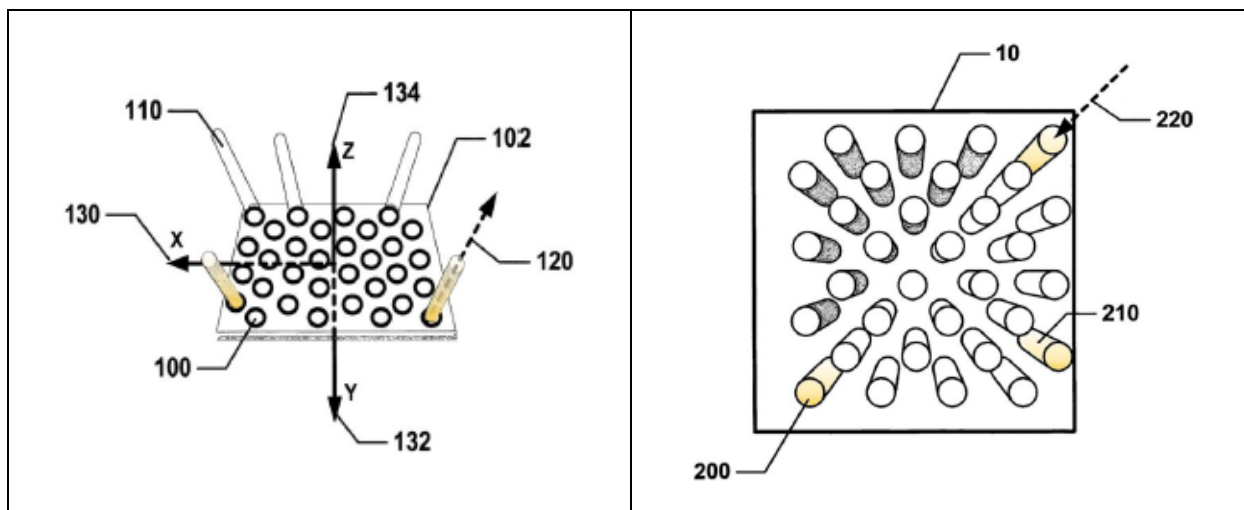
1. The Retterath-Based Grounds Fail to Disclose the Claimed Pixels with Fields of View Coincident with the Emission Regions of Corresponding or Paired Optical Emitters

Claim 1 recites a plurality of emitters and a plurality of pixels, wherein “each pixel in the plurality of pixels has a field of view coincident with an emission region of a corresponding optical emitter in the plurality of optical emitters.” (EX1001, claim 1.) Claim 14 has a similar requirement. (*Id.*, claim 14 (reciting “a plurality of pixels arranged behind the bulk imaging optic . . . , wherein each pixel in the plurality of pixels . . . has a field of view coincident with an emission region of its paired optical emitter”); EX2009, ¶¶161-62).

Petitioner contends that Retterath satisfies this limitation because it discloses that “emitter and detector vectors are coincident and form a common on-coincident axis[.]” (Pet. at 26-28 (quoting EX1005, 6:23-39).) In other words, Petitioner asserts that because corresponding or paired emitters and detectors in Retterath’s system have a shared directional *axis*, they are “coincident with” each other. Petitioner’s expert confirmed this understanding in his deposition, testifying that all the “coincident” limitation requires is correspondence between the “vector,” *i.e.*, the directional axis, of an emitter and detector. (EX2010, 34:1-15.)

To show that the “**each pixel in the plurality of pixels has a field of view coincident with an emission region of [a corresponding/its paired] optical emitter**” limitation is satisfied, Petitioner provides the following demonstrative

diagrams based on the figures of Retterath to show that emitter directional axis **120** matches detector directional axis **220**:



(Pet. at 28 (EX1005, FIG. 4 (annotated)); *id.* at 27 (EX1005, FIG. 8 (annotated)).)

Petitioner did not expressly offer any proposed claim construction for **“each pixel in the plurality of pixels has a field of view coincident with an emission region of [a corresponding/its paired] optical emitter.”** Because Petitioner’s Retterath-based grounds are based on an incorrect interpretation of **“each pixel in the plurality of pixels has a field of view coincident with an emission region of [a corresponding/its paired] optical emitter,”** those grounds fail.

- (a) **The Term “Each Pixel in the Plurality of Pixels has a Field of View Coincident with an Emission Region of [a Corresponding/its Paired] Optical Emitter” Requires Substantially the Same *Area*—Not Merely the Same Direction**

Based on the specification of the ’381 patent and the extrinsic evidence, the term **“each pixel in the plurality of pixels has a field of view coincident with an**

emission region of [a corresponding/its paired] optical emitter” should be construed to mean that the field of view of each pixel and the emission region of a corresponding [or paired] optical emitter cover substantially the same area in the field. (EX2009, ¶¶108-22.) Petitioner’s construction is consistent with the intrinsic evidence.

Federal Circuit law is clear that “the claims themselves provide substantial guidance as to the meaning of particular claim terms.” *Phillips v. AWH Corp.*, 415 F.3d 1303, 1314 (Fed. Cir. 2005) (en banc). The plain language of claim 1 recites that “**each pixel in the plurality of pixels has a field of view coincident with an emission region of [a corresponding/its paired] optical emitter.**” The claim makes clear the claimed coincidence must be with “a **field** of view” and an “**emission region**,” and not merely a directional axis. “[F]ield of view,” as the term itself implies, refers to a range of the observable world that is visible, in this case to the emitter and its corresponding or paired pixel in the plurality of pixels. (EX2009, ¶120.) The claim language itself thus requires substantial similarity *of the visible area* between the emitter that outputs light and its corresponding or paired pixel. Because Petitioner’s implicit interpretation rests on an attempt to rewrite the claim to replace “**field** of view” with “a **direction** of view,” and “**emission region**” with “a **direction** of emission,” it should be rejected. (*Id.*, ¶120; *see, e.g., K-2 Corp. v. Salomon S.A.*, 191 F.3d 1356, 1364 (Fed. Cir. 1999) (“Courts do not rewrite claims;

instead, we give effect to the terms chosen by the patentee.”).

The specification further supports Patent Owner’s construction. As the Federal Circuit has held, the patent specification “is always highly relevant to the claim construction analysis. Usually, it is dispositive; it is the single best guide to the meaning of a disputed term.” *Phillips*, 415 F.3d at 1315 (quoting *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996)). The corresponding written description of this claim limitation is shown in Figure 1:

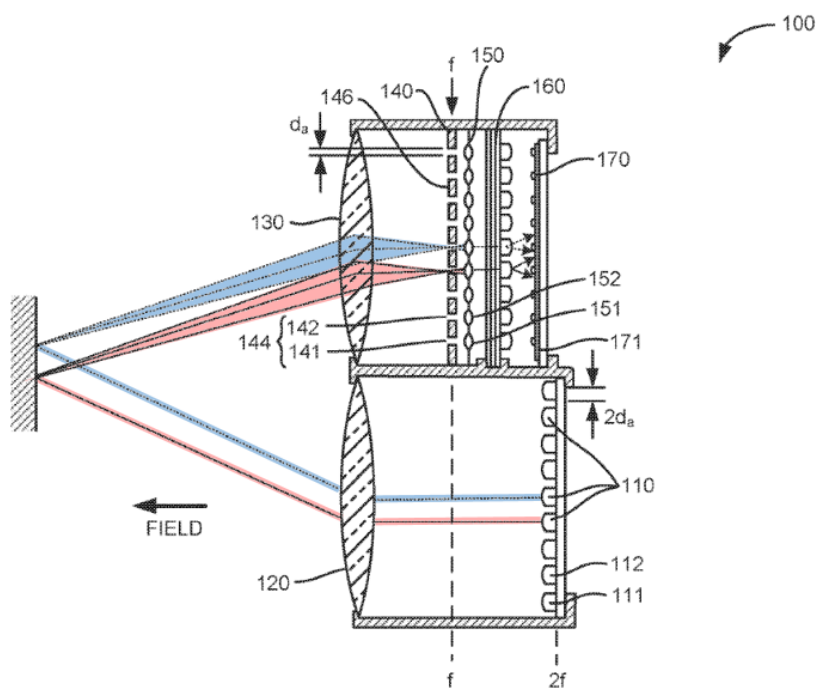


FIG. 1

(EX2009, ¶112.) Each emitter shines light onto a different area in the field, and that light bounces off the field and reaches a particular corresponding or paired detector.

(*Id.*) The written description explains that “each illumination source in the set of illumination sources **110** [is] configured to output an illuminating beam of an

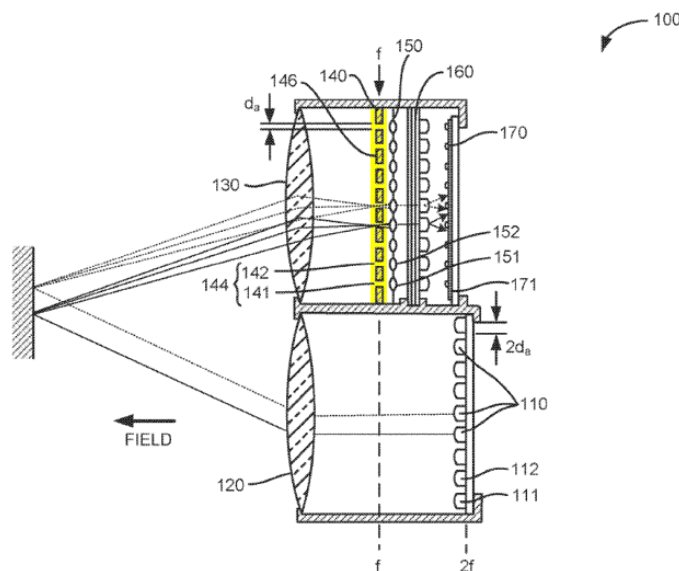
operating wavelength toward a discrete spot in the field ahead of the illumination source[.]” (EX1001, 10:62-66.)

The ’381 patent makes clear that the region (“discrete spot”) illuminated by each emitter’s light matches the field of view of a corresponding or paired detector. The ’381 patent specification indicates that each aperture **144** in Figure 1 “defines a **field of view in the field coincident a discrete spot** by a corresponding illumination source.” (EX1001, 3:61-4:1 (emphasis added).) Accordingly, the specification uses the term “coincident” to mean that one area (the field of view of an aperture) matches another (the “discrete spot” of an illumination source). (EX2009, ¶111.)

The ’381 patent specification indicates that this matching between emission regions and detector fields of view is “substantial[.]” matching. (EX2009, ¶¶111, 113-14.) For example, the ’381 patent discloses that the system “selectively project[s] illuminating beams into a field ahead of the system according to an illumination pattern that **substantially matches**—in size and geometry across a range of distances from the system—the fields of view of the apertures.” (EX1001, 2:67-3:4; *see also* EX2009, ¶111.)

Additionally, the ’381 patent indicates that the substantial matching of emission and detection regions is important to its system’s design and efficient operation. (EX2009, ¶¶113-14.) For example, “minimal power output by the system (via the illumination sources) is wasted by illuminating surfaces in the field for

which the pixels are blind.” (EX1001, 3:4-12.) Further, matching emission and detection regions between pairs of corresponding or paired emitters and detectors leads to “a relatively high ratio of light rays originating from the first illumination source **111** to light rays originating from other illumination sources in the system.” (*Id.*, 6:12-37.)



(EX2009, ¶121 (showing EX1001, FIG. 1 with colored annotations added).) Just as “coincident with” in claims 1 and 14 indicates substantially the same emission and detection regions, “coincident with” in reference to the Figure 1 aperture layer indicates substantial coverage of the focal plane. (*Id.*, ¶121.)

The extrinsic evidence further supports Patent Owner’s construction. For example, the term “coincident” is defined as “[o]ccupying the same place or portion of space.” (EX2011 (Oxford English Dictionary (1989)) at 8.) This definition supports Patent Owner’s construction, because it indicates that the **“each pixel in the plurality of pixels has a field of view coincident with an emission region of [a corresponding/its paired] optical emitter”** limitation should be understood to relate to overlap in the “same place or portion of space.” (EX2009, ¶122.) Petitioner’s apparent understanding that this limitation can encompass mere directional correspondence is inconsistent with the dictionary definition’s requirement of occupying the “*same* place or portion of space.” *Id.*

Petitioner and its expert’s apparent understanding of the **“each pixel in the plurality of pixels has a field of view coincident with an emission region of [a corresponding/its paired] optical emitter”** term is inconsistent with the intrinsic and extrinsic evidence and should be rejected. (EX2009, ¶¶115-22.) As noted, Petitioner’s expert testified that, in his view, “coincident” simply means “overlapping.” (EX2010, 97:8-10.) He further testified that an emitter and detector

need only share a directional vector or axis to be “coincident” with each other—regardless of the *area* of the associated emission and detection regions. (*Id.*, 33:17-20, 34:1-15, 35:7-10, 35:14-36:2.)

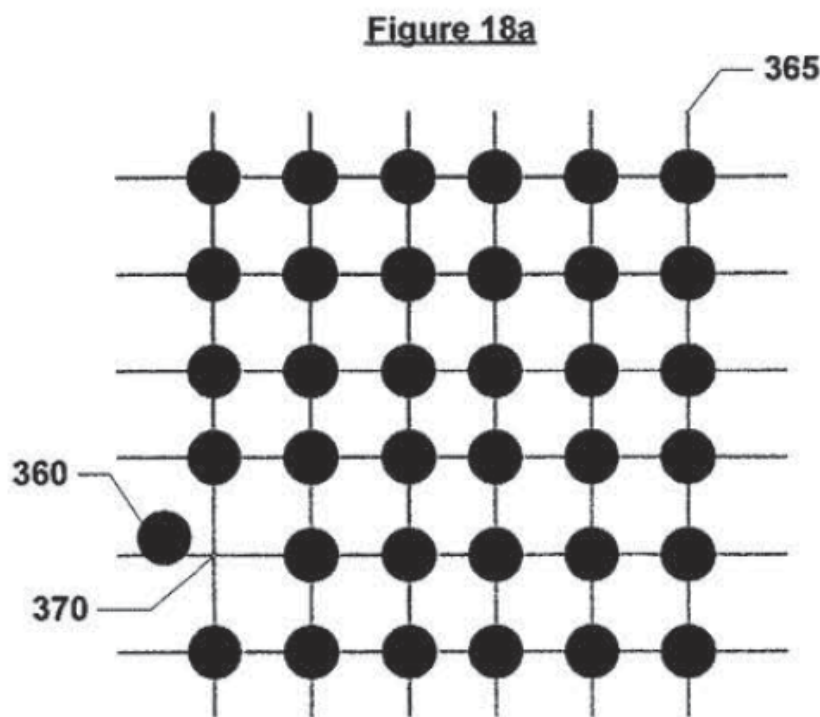
(b) The Retterath-Based Grounds Fail to Disclose That the Emitters and Detectors Cover Substantially the Same Areas.

Petitioner relies for Grounds 1A, 1B, and 1C on Retterath’s disclosures to show that that the **“each pixel in the plurality of pixels has a field of view coincident with an emission region of [a corresponding/its paired] optical emitter”** term is satisfied for claims 1 and 14. (Pet. at 26-29, 42-43, 46-48.) Because Retterath does not disclose an emitter and corresponding or paired detector with substantially the same area, Retterath fails to disclose claim 1 or 14. (EX2009, ¶¶130-37, 173-74, 181-82.)

Petitioner states that Retterath discloses that each pair of emitters and detectors has a “common on-coincident axis that is at an angle relative to a vector normal to the plane of the array that is unique for that emitter/detector set.” (Pet. at 26-28 (quoting EX1005, 6:23-39).) Petitioner appears to assert that because each pair of emitter and detector pairs has a unique shared directional axis, Retterath discloses that each detector has a **“each pixel in the plurality of pixels has a field of view coincident with an emission region of [a corresponding/its paired] optical emitter”** per claims 1 and 14. But under a correct understanding of that

phrase, Retterath fails.

Retterath does not disclose substantial correspondence between the *area* illuminated by an emitter and the field of view of a detector. (EX2009, ¶134.) Retterath discloses in reference to the emitters that “a smaller round spot **94** size” is advantageous because it “will generally reduce or remove crosstalk with detectors that are near the on-coincident axis matched detector for” an emitter. (EX1005, 9:36-44 (emphasis added), FIG. 7.) For example, Figure 18a of Retterath shows an “ideal location **370** for emitted beams” in its system:



(EX1005, FIG. 18a.) These points show a grid pattern of laser beams, each beam having a significant gap between neighboring beams. Because LIDAR uses lasers to generate the emitted beams, the beams will not spread out or disperse significantly

during their travel from the emitter to the destination. (EX2009, ¶134; EX1005, 1:18-20 (“LiDAR... uses laser technology to make precise distance measurements over short or long distances.”).)

And even more fundamentally, there is simply no disclosure in Retterath that the emitters and detectors cover substantially the same area. Retterath instead consistently discloses that emission regions of emitter do *not* substantially match the field of view of a corresponding or paired detector or detectors. (EX1005, 11:33-37 (“Since the vectors are similar, emitted energy from one emitter will possibly be received at a detector that is not its pair.”); EX2009, ¶135; *see also* EX1005, FIGS. 19-20, 17:43-46 (disclosing “a plurality of detector elements for each emitter element”), 17:58-60 (disclosing “secondary detectors” around a primary detector for receiving light from an emitter), 18:29-32 (disclosing “tertiary detectors”).)

Retterath discloses that smaller emission regions reduce cross-talk, which Retterath indicates is a major issue for a system with multiple laser emitters such as it discloses. (EX2009, ¶136.) For example, in the “Field of the Invention” section of the ’381 patent specification, it states that “the present invention relates to non-scanning LiDAR systems using an array of emitter/detector sets to cover a given field of view that provides for **reduced interference due to crosstalk among emitters within a given LiDAR unit** and also among different LiDAR units.” (EX1005, 1:9-14 (emphasis added).) Retterath further discloses that for systems

with multiple laser emitters like what it discloses, “[c]are must be taken to ensure that signals received by the photoreceptor are reflected light from the desired emitted source.” (*Id.*, 5:55-57; *see also id.*, 5:63-67.)

None of Petitioner’s asserted permutations of the art in the Retterath-based combinations (Grounds 1A to 1G) satisfies the “**each pixel in the plurality of pixels has a field of view coincident with an emission region of [a corresponding/its paired] optical emitter**” claim limitation as properly understood. (EX2009, ¶¶174, 182.) The Borowski, Hipp, and Pacala references in these grounds do not appear to change the analysis for the “**each pixel in the plurality of pixels has a field of view coincident with an emission region of [a corresponding/its paired] optical emitter**” limitation in any way. (Pet. at 42-43, 46-48.)

Only the Weimer reference appears to impact Petitioner’s argument for the “**each pixel in the plurality of pixels has a field of view coincident with an emission region of [a corresponding/its paired] optical emitter**” claim limitation (for Grounds 1D, 1E, 1F, 1G). (Pet. at 50-54.) But Weimer does not satisfy this limitation as properly construed either, because Weimer—like Retterath—discloses emission regions that are *smaller* than the detector fields of view. (EX2009, ¶194.) For example, Petitioner relies on Figure 2A of Weimer, reproduced below:

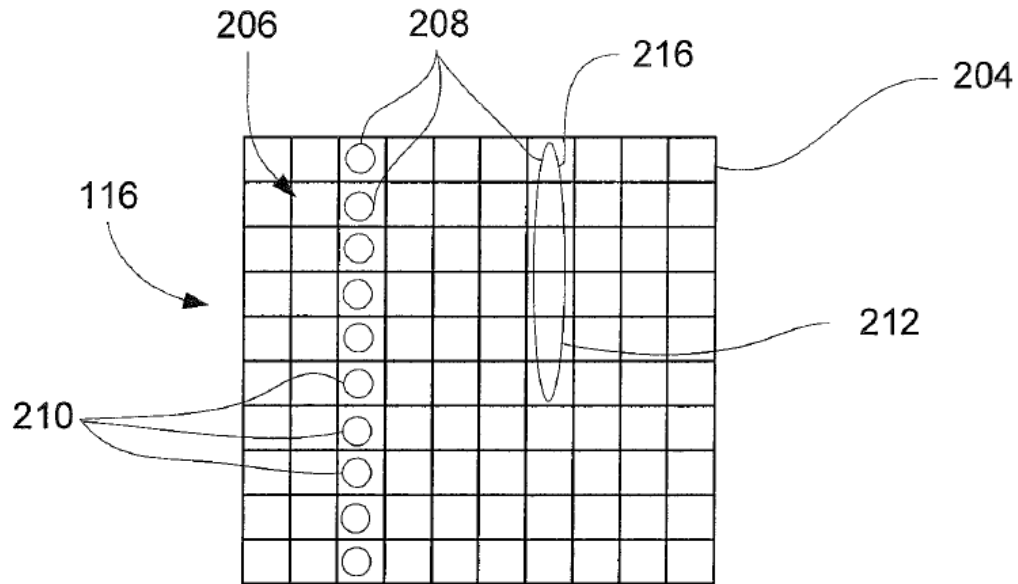


Fig. 2A

(Pet. at 53 (EX1008, FIG. 2A).)

However, as Figure 2A that Petitioner relies upon makes clear, Weimer's **emission regions** are significantly **smaller** than the **field of view** of its detectors:

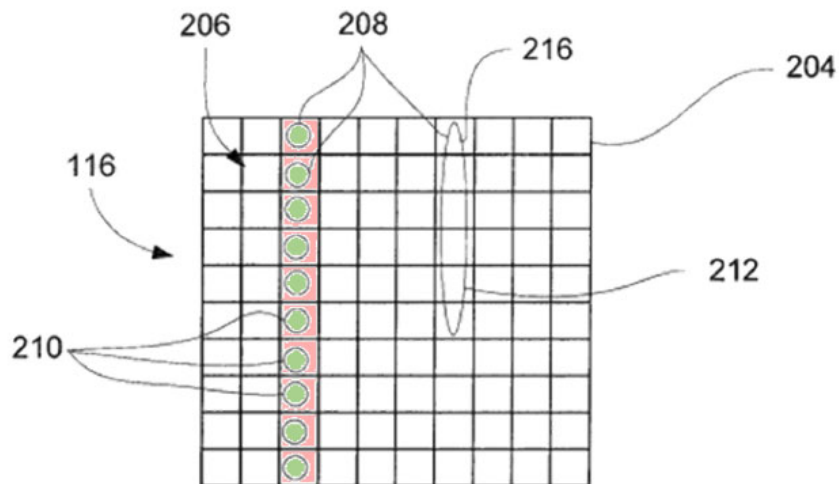


Fig. 2A

(EX2009, ¶193-95.) Indeed, Weimer indicates that a “laser spot size only slightly

smaller than the receiver's instantaneous field of view" is an important design consideration for its system to achieve "good daytime performance." (EX1008, 1:56-59.) Weimer discloses emission regions smaller than detector fields of view throughout its various embodiments. (See EX1008, FIGS. 2A-J; EX2009, ¶196.)

Accordingly, none of Grounds 1A to 1G satisfy the **"each pixel in the plurality of pixels has a field of view coincident with an emission region of [a corresponding/its paired] optical emitter"** requirement of claims 1 and 14 as properly construed, or any of the remaining challenged claims that all depend from claims 1 or 14. (EX2009, ¶¶130-37, 161-62, 173-74, 175-76, 181-82, 191-97, 204-07, 208-10.)

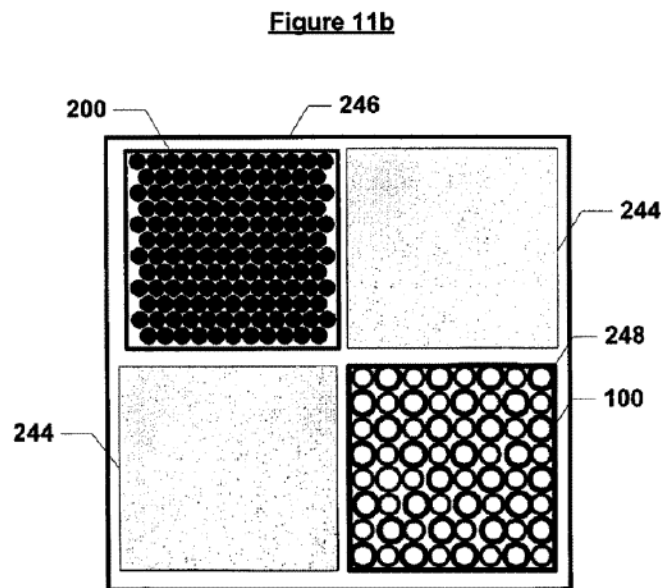
2. The Retterath-Based Grounds Fail to Disclose the Claimed Bulk Transmitting Optic Disposed Adjacent to the Bulk Imaging Optic

Claim 1 of the '381 patent recites two separate bulk optics, *i.e.*, **"a bulk transmitting optic"** and **"a bulk imaging optic disposed adjacent to the bulk transmitting optic."** These bulk optics pertain, respectively, to the "imaging" side (which detects light returning from the external field into the system) and the "transmitting" side (which emits light into the external field) of the claimed optical imaging system.

The plain language of the claims, as noted, requires that the bulk transmitting optic must be disposed **"adjacent to"** the bulk imaging optic, which necessarily

requires two separate bulk optics (*e.g.*, lenses). Petitioner's grounds based on Retterath fail because, as shown below, they fail to disclose or render obvious separate bulk optics (*e.g.* lenses) for imaging and transmitting.

The Petition relies on Figure 11b of Retterath, which shows detector array **200** and emitter array **100** formed in regions **246** and **248**, respectively:



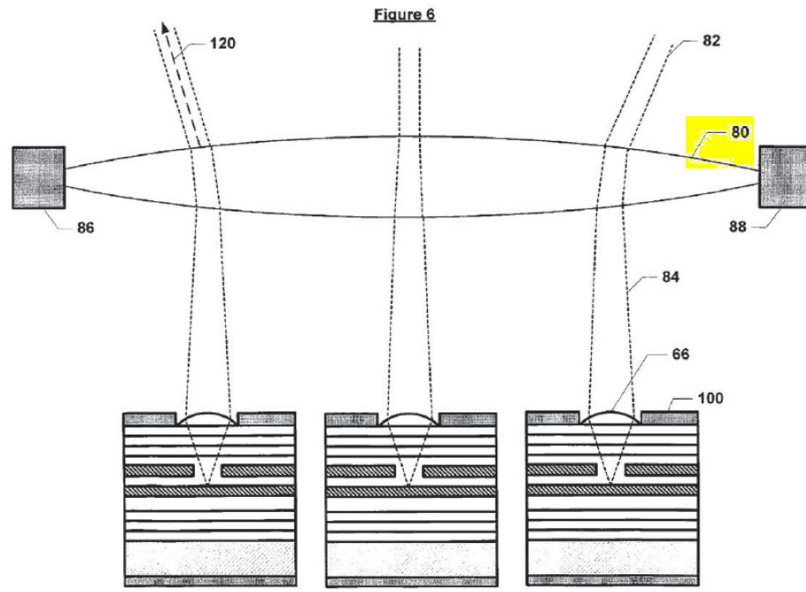
(EX1005, FIG. 11b; Pet. at 25.) Petitioner relies on detector array **200** for the claimed **“plurality of pixels arranged behind the bulk imaging optic,”** and on emitter array **100** for the claimed **“plurality of optical emitters arranged behind the bulk transmitting optic.”**

But Retterath does not disclose separate bulk optics (*e.g.* lenses) for detector array **200** and emitter array **100** as shown in Figure 11b. (EX2009, ¶126.) To the extent Retterath provides any disclosure of bulk optics for detector array **200** and emitter array **100**, it indicates that a single lens is used. (*Id.*) For example, in the

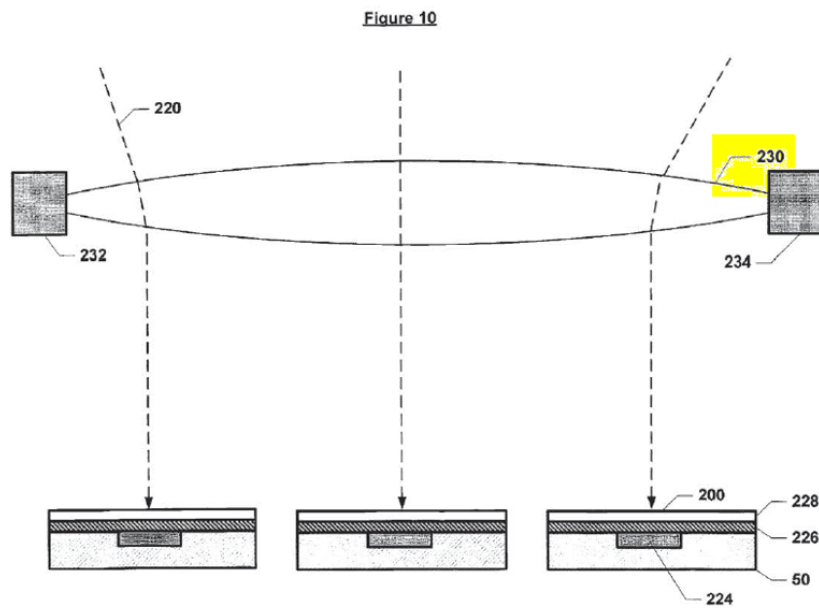
discussion of the related embodiment in Figure 11a, Retterath discloses the use of a “single global lens [that] can be utilized for both emitter elements **100** and detector elements **200**.” (EX1005, 10:50-51 (emphasis added), 11:10-15 (discussing “global lens detectors”); EX2009, ¶126.)¹ Retterath also discloses how to adapt Figure 11a’s “single global lens” embodiment to an embodiment with “[l]arger distances between micro-lens emitter elements and waveguide detector elements,” like what is shown in Figure 11b. (EX1005, 10:58-60.) There is no disclosure, for either Figure 11a or 11b, of separate bulk optics for the detector **200** and emitter **100** arrays.

Without providing any evidence or analysis to support the combination, Petitioner appears to combine Retterath’s Figure 11b embodiment with the embodiments shown in Figures 6 and 10. (Pet. at 24-26; EX2009, ¶¶127-28.) For example, from Figure 6, Petitioner relies on “macro lens **80**”:

¹ Retterath’s discussion of Figure 11a discloses an alternative embodiment using “micro lens” for emitter elements **100** (EX1005, 10:54-56), but a “micro lens,” as its name implies is the opposite of a “bulk” optic. A micro lens is instead a lens specific to a particular emitter. (*Id.*, Fig. 5a (showing emitter lens **66**), 4:46-48 (“FIGS. 5a and 5b illustrate the functional layers of a vertical emitter with a micro lens according to an embodiment.”).) Retterath does not disclose the use of separate bulk optics for the emitter elements **100** and the detector array **200** as explained in the text.



(EX1005, FIG. 6 (highlighting added).) And from Figure 10, Petitioner relies on “macro detector lens **230**”:



(EX1005, FIG. 10 (highlighting added).)

In other words, Petitioner appears to assert (without saying so or providing any evidence or argument in support) that a POSITA would have taken the Figure

11b embodiment and used *two* lenses disclosed in *other* Retterath embodiments—even though a “single global lens” is disclosed for the related Figure 11a embodiment.

Petitioner thus appears to be attempting to combine disclosures from Retterath in order to arrive at the claimed invention. “An obviousness determination requires finding both ‘that a skilled artisan would have been motivated to combine the teachings of the prior art ... and that the skilled artisan would have had a reasonable expectation of success in doing so.’” *In re Stephan*, 868 F.3d 1342, 1345-46 (Fed. Cir. 2017). This requirement not only applies when multiple different references are combined, but also when the disclosures within a *single* reference are combined to arrive at the claimed invention. *Id.* at 1346 n.1 (“Whether a rejection is based on combining disclosures from multiple references, combining multiple embodiments from a single reference, or selecting from large lists of elements in a single reference, there must be a motivation to make the combination and a reasonable expectation that such a combination would be successful, otherwise a skilled artisan would not arrive at the claimed combination.”) (emphasis added). Petitioner offers no motivation to combine the disclosures in Retterath as proffered. A POSITA would instead have been motivated to use fewer elements where possible in order to minimize cost and size requirements. (EX2009, ¶128.) It thus makes sense that Retterath discloses a “single global lens” in connection with the embodiment of

Figure 11b. Petitioner does not explain why a POSITA would have been motivated to take a *single* global lens and split it up into *two* lenses. Indeed, Petitioner’s expert himself opined that a POSITA would have been motivated to make Retterath’s system compact and low-cost. (EX1003, ¶¶223; *see also id.*, ¶¶ 181, 225.)

Petitioner’s Grounds 1A, 1B, 1D, and 1F all rely on Retterath for the “bulk imaging optic disposed adjacent to the bulk transmitting optic” limitation. (Pet. at 27-28, 37-40, 43-44; EX2009, ¶¶125, 172, 190, 209) Because Retterath fails to disclose “a bulk transmitting optic disposed adjacent to the bulk imaging optic,” all of Petitioner’s Grounds 1A, 1B, 1D, and 1F fail to satisfy this limitation. (EX2009, ¶¶124-29, 171-72, 189-90, 209.)

Grounds 1C, 1E, and 1G rely on the combination of Retterath and Pacala for the “bulk imaging optic disposed adjacent to the bulk transmitting optic” limitation. But Petitioner relies on the assumption that Retterath discloses the use of two bulk optics in the context of the Figure 11b embodiment—asserting that it would have been obvious to arrange those two lenses in light of Pacala. (Pet. at 46, 54, 55.) As discussed above, Retterath does not disclose—and Petitioner does not provide the necessary analysis to support—the use of two lenses for the Figure 11b embodiment. Further, as Petitioner’s expert indicates, Pacala’s low-cost, compact rotating LIDAR system only *increases* the impact considerations of space, weight, and cost would have had for a POSITA’s calculus. (EX1003, ¶¶223, 225, 250, 316.) Accordingly,

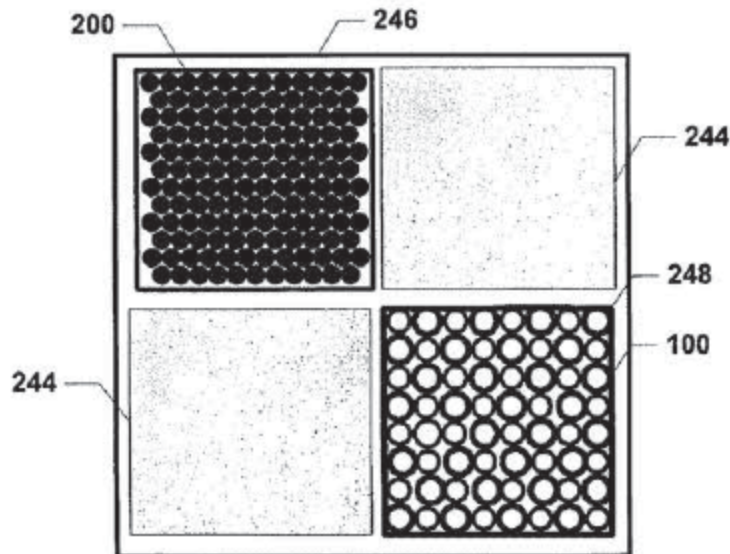
the addition of Pacala to the Retterath combinations does not change the fact that a POSITA would not have been motivated to use two lenses in Retterath's relied-upon Figure 11b embodiment. (EX2009, ¶¶177-80, 208, 210.)

Accordingly, claim 1 and the challenged dependent claims should be found not to be unpatentable over any of the Retterath-based grounds.

3. The Retterath-Based Grounds Do Not Satisfy Dependent Claim 3

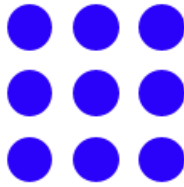
Dependent claim 3 requires that the optical emitters of claim 1 are “arranged in a first arrangement,” and the pixels are “arranged in a second arrangement, proportional to the first arrangement.” Petitioner relies on Retterath's disclosure for claim 3 as to each of the Retterath-based grounds. (Pet. at 30, 42-43, 46-48, 52-55.) But all Petitioner can point to for the “proportional to the first arrangement” limitation is that Retterath discloses using the same *number* of emitters and pixels. (Pet at 30.) However, nothing in Retterath indicates that the emitters and pixels have a proportional *arrangement*. (EX2009, ¶¶140-45.) In fact, Figure 11b (which Petitioner relies on), shows two entirely different arrangements of emitters and detectors—which a POSITA would not have considered “proportional”:

Figure 11b

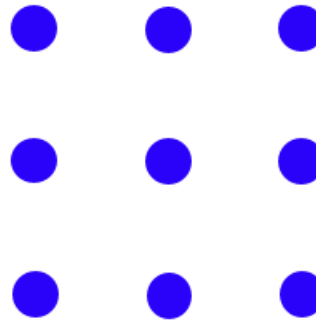


(EX1005, Fig. 11b; EX2009, ¶¶139-43.) The emitters **100** are shown to be in a square grid arrangement—whereas the detectors **200** are in a non-proportional diagonal arrangement. (EX2009, ¶141.)

A POSITA would have considered proportional arrangements to be arrangements that are related by a scaling factor. (EX2009, ¶142.) For example, a POSITA would have considered the below arrangements to be proportional, because the elements have the same basic pattern, but the elements in arrangement (b) are twice as far apart from each other as compared to the elements in arrangement (a).



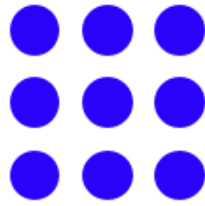
(a)



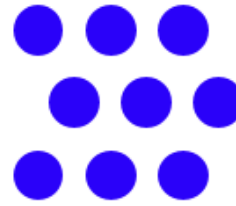
(b)

(*Id.*) A POSITA would not have considered the arrangements of emitters and detectors in Retterath’s Figure 11b to be “proportional” because the pattern of elements is different—*i.e.*, the difference between arrangements cannot be reduced to a scaling factor.

A POSITA would not have considered two arrangements to be “proportional” simply because they have the same number of elements. (EX2009, ¶¶144-45.) For example, the following two arrangements have the same number of elements, but a POSITA would not have considered them to be “proportional,” because they have a different pattern:



(a)



(b)

(*Id.*, ¶144.)

Accordingly, none of the Retterath-based grounds satisfy claim 3 of the '381 patent. (EX2009, ¶¶138-46, 183-84, 198-99, 208.)

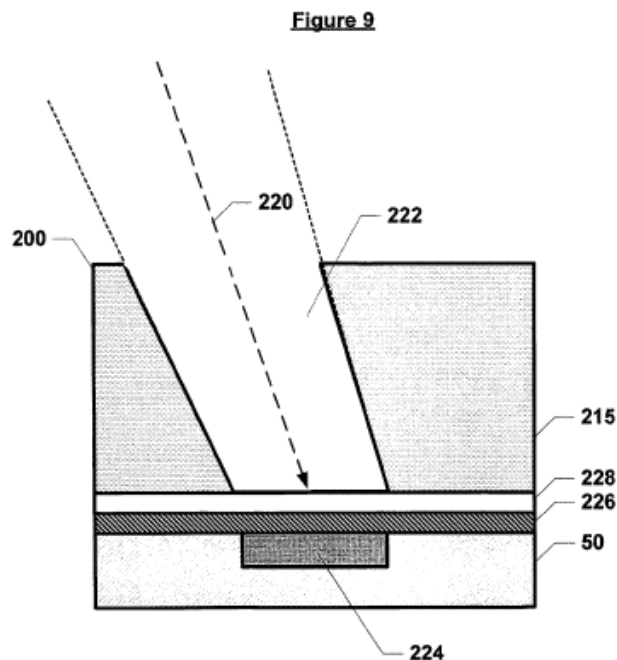
4. The Retterath-Based Grounds Do Not Satisfy Dependent Claim 7

Claim 7 of the '381 patent recites: “The optical system according to claim 6 wherein the aperture layer comprises a thin opaque structure.” Petitioner fails to show that the Retterath-based grounds satisfy the “opaque” limitation. (EX2009, ¶¶154-60.) The structure of Retterath that Petitioner relies on is semi-transparent—not opaque. Apparently recognizing the limitations with Retterath, Petitioner attempts to combine Retterath and Borowski with Hipp’s “shadow mask.” But a POSITA would not have been motivated to combine the Retterath-Borowski combination—based on noise-prone SPADs—with Hipp’s shadow mask, which

causes noise and interference due to reflections. (EX2009, ¶¶166-70.) Accordingly, Petitioner’s Retterath-based grounds must fail for claim 7.

(a) Retterath Does Not Disclose or Render Obvious an Aperture Layer Consisting of an “Opaque Structure”

For Grounds 1A, 1C, 1D, and 1E, Petitioner relies on the disclosures of Retterath for claim 7. Specifically, Petitioner asserts that Retterath’s waveguides **222** and waveguide material **215** are an aperture layer comprising a thin opaque structure. (Pet. at 34.) Figure 9 shows a waveguide **222** with waveguide material **215**:



EX1005, Fig. 9.

However, Retterath discloses that its waveguide material **215** is not opaque. Rather, Retterath discloses that waveguide material **215** only “partially reduce[s] in intensity” or “substantially” blocks light. EX1005, 9:59-65, 10:14-17. The only

light Retterath indicates that waveguide material **215** absorbs is light with “the wavelength or range of wavelengths of the emitted light.” EX1005, 10:14-17. Retterath does not indicate the waveguide material **215** absorbs or blocks any other wavelengths of light—*e.g.*, stray light from the environment. Indeed, Retterath’s disclosure of “partial[]” or “substantial[]” blocking of light suggests that there are wavelengths of light that Retterath’s waveguide material **215** does **not** block or absorb. (EX2009, ¶157.)

Since Retterath’s waveguide material **215** is partially transparent to certain light, Retterath’s waveguide material does not constitute an “opaque structure” per claim 7. (EX2009, ¶158.) Dr. Shanley appears to agree. When asked in his deposition if waveguide material **215** is still opaque if light can get through that layer, Dr. Shanley testified that “if it’s an opaque material, it shouldn’t, and if you choose your material right, it shouldn’t.” (EX2010, 76:1-18.)

The ’381 patent confirms that partial or substantial absorption of some light does not indicate an “opaque” material. For example, when the ’381 patent specification discusses “opaque” materials, those materials completely absorb or block light. (EX2009, ¶159.) There is no suggestion in the ’381 patent that an opaque material could let some light through. (*Id.*) For example, in Figure 9, reproduced below, the ’381 patent identifies an “opaque polymer”:

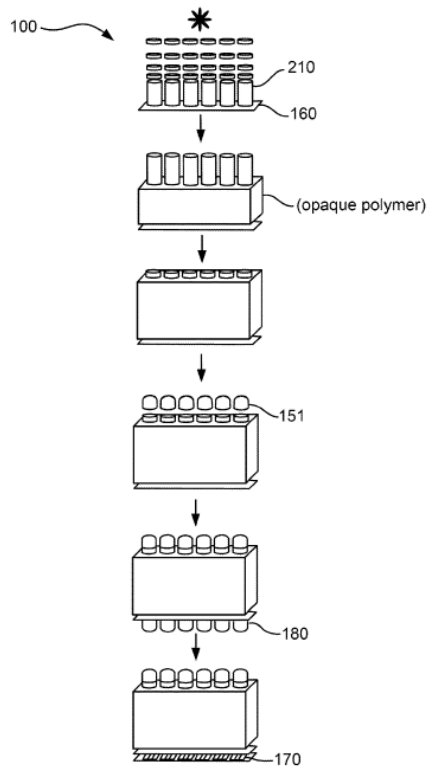


FIG. 9

(EX1001, Fig. 9.) The '381 patent specification indicates that this “opaque polymer” is a “light-absorbing polymer.” (*Id.*, 13:63-64; *see also id.*, 4:40-46 (disclosing “a stop region **146** (i.e., an opaque or reflecting region) between adjacent apertures such that the apertures define discrete, non-overlapping fields of view”), 13:32-35 (disclosing an “opaque cylindrical wall . . . configured to absorb incident light rays”).)

Despite Retterath’s lack of disclosure of an aperture consisting of a truly “opaque structure,” Petitioner attempts to salvage it by providing a brief paragraph based on the say-so of its expert that use of “opaque” material would have been obvious to use in Retterath given the “stated goal of blocking light that is not

intended for a particular pixel.” (Pet. at 34; EX2009, ¶160.) But Retterath discloses the use of non-opaque, partially transparent waveguide material in its system meet this goal of blocking unintended light. (EX1005, 9:59-65.) Accordingly, a POSITA would not have been motivated to change Retterath’s design, when Retterath discloses that a partially transparent waveguide material would be sufficient in the context of its system.

(a) A POSITA Would Not Have Been Motivated to Combine Hipp’s “Shadow Mask” with the Retterath-Borowski Combination

Petitioner further asserts (for Grounds 1B, 1F, and 1G) that the Retterath-Borowski-Hipp combination would have rendered obvious the “opaque material” limitation of claim 7. However, a POSITA would not have been motivated to make this combination.

The Retterath-Borowski-Hipp combination uses Borowski’s SPAD arrays and Hipp’s “shadow mask” in Retterath’s LIDAR system. (Pet. at 39-40.) A POSITA would not have been motivated to implement Hipp’s “shadow mask” with the Retterath-Borowski combination. (EX2009, ¶¶166-70.) In one embodiment of Hipp, the patent discusses implementing a “shadow mask” to only transmit light that is “incident on the active zones of the APDs.” (EX1007, 21:57-60.) Hipp states that some of the light that passes through the shadow mask could be reflected by the photodetectors (APDs) and reflected back from the lower side of the shadow mask

and scattered, reaching the “adjacent active zones” of the APDs and “act[ing] as an interference signal there.” (*Id.*, 22:1-7.)

A POSITA would have understood that these noise and interference issues with Hipp’s “shadow mask” would have made them incompatible with the SPAD-based detectors of the Retterath-Borowski combination. (EX2009, ¶169.) A POSITA would have understood that the SPADs in the proposed Retterath-Borowski combination are significantly more sensitive to noise and interference than the APDs described in Hipp. (*Id.*) Unlike an APD, a SPAD is so sensitive that it can be triggered by a single photon. Dr. Shanley himself cautions in his declaration that noise and interference in SPAD based systems is “particularly problematic” because “even a single errant photon may cause a false positive detection, while also rendering the SPAD inoperable until it is quenched.” (EX1003, ¶55.)

Accordingly, any errant photon reflected from the lower side of Hipp’s shadow mask could trigger—and render temporarily blind—an adjacent SPAD. Such interference would impact the system’s ability to distinguish light relevant to the LIDAR system (*e.g.*, light pulses from the system’s emitters reflected from the field) from undesired reflections of light within the proposed Retterath-Borowski-Hipp combination. (EX2009, ¶¶168-69.)

A POSITA would not have been motivated to implement Hipp’s shadow mask in SPAD-based system without making substantial modifications to the system to

address the risk of interference from light scattered by the underside of Hipp's shadow mask. (EX2009, ¶¶169.) But neither Petitioner nor its expert address or even *acknowledge* any of the potential interference issues that Hipp's shadow mask would cause in a SPAD-based system. (*See, e.g.*, EX1003, ¶¶196-201.)

Since a POSITA would not have been motivated to make the Retterath-Borowski-Hipp combination on which Petitioner bases Grounds 1B, 1F, and 1G for claim 3 of the '381 patent, these grounds must fail as to claim 3.

5. The Retterath-Based Grounds Do Not Satisfy Dependent Claims 6 or 17

Claims 6 and 17 require an “aperture layer . . . comprising a plurality of apertures separated by a stop region.” A POSITA would have understood that the “stop region” claim limitation requires an opaque structure. But Petitioner points to the partially transparent (*i.e., not* opaque) waveguide material **215** in Retterath as the “stop region”—the same material discussed above in connection with the claim 7 “opaque structure” limitation. (Pet. at 31, 38.) Further, Petitioner seeks to use the Retterath-Borowski-Hipp combination to satisfy the “stop region” limitation. (Pet. at 42-43.) But, as discussed above, the Retterath-Borowski-Hipp combination would not have been obvious to a POSITA. (*See* EX2009, ¶¶166-70.) Accordingly, Petitioner has failed to show that claims 6 or 17 are satisfied by the Retterath-based grounds.

The '381 patent confirms that partial or substantial absorption of some light

does not indicate a “stop region.” Rather, the ’381 patent specification indicates that a “stop region” refers to an opaque or reflecting material—not a partially transparent material. (EX2009, ¶151.) For example, the ’381 patent discloses “the aperture layer **140** defines a stop region **146** (i.e., an opaque or reflecting region)[.]” EX1001, 4:42-43 (emphasis added). The ’381 patent further discloses that “light rays incident on a stop region **146** of the aperture layer **140** are rejected (e.g., mirrored or absorbed)[.]” *Id.*, 3:43-45 (emphasis added); *see also id.*, 4:1-4, 5:7-22 (“a stop region . . . blocks light rays . . . from passing”), claim 26 (reciting that a “stop region . . . blocks light rays”). Further, the ’381 patent indicates that it is important for stop regions to “block photons,” because in blocking light, they “reduc[e] crosstalk” between optical channels. *Id.*, 6:1-5.

Petitioner and its expert fail to provide *any* evidence for its apparent interpretation of the “stop region” claim language as a region that “substantially block[s]” light. (Pet. at 31; EX2009, ¶152.) In fact, Petitioner’s expert testified that *no* light should get through an opaque material like what the ’381 patent requires for the “stop region” limitation. When asked in his deposition if waveguide material **215** is still opaque if light can get through that layer, Dr. Shanley testified that “if it’s an opaque material, it shouldn’t, and if you choose your material right, it shouldn’t.” EX2010, 76:1-18.

B. The Board Should Reject Grounds 2A-C

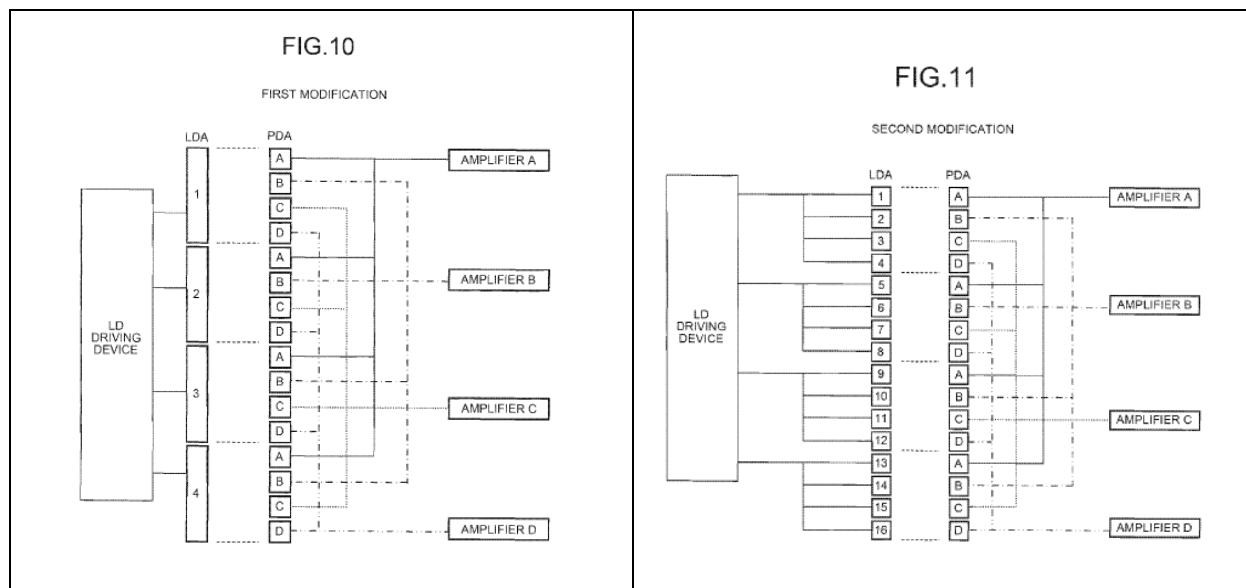
In Grounds 2A-C (the “Imai-based grounds”), Petitioner relies on Imai for its overall optical system design and Higashi for the use of multi-SPAD pixels. (Pet. at 44-50.) Further, Petitioner relies on Grzesik’s disclosure of “absorption layers” for the “aperture layer” limitations of the challenged claims. (*Id.* at 50-53.) Additionally, Petitioner relies on Pacala’s rotating LIDAR system for the “rotation” limitations of dependent claim 5.

1. The Imai-Based Grounds Fail to Disclose Pixels with Fields of View Coincident with Emission Regions of Corresponding or Paired Optical Emitters

As discussed above, the **“each pixel in the plurality of pixels has a field of view coincident with an emission region of [a corresponding/its paired] optical emitter”** limitations in claims 1 and 14 of the ’381 patent should be construed to mean that the field of view of each pixel and the emission region of a corresponding [or paired] optical emitter cover substantially the same area in the field. The Imai-based grounds fails to satisfy claims 1 or 14 because Imai only discloses emission regions that are significantly larger or smaller than the detection regions of the corresponding or paired detectors.

Petitioner relies on the disclosures of Imai for the **“each pixel in the plurality of pixels has a field of view coincident with an emission region of [a corresponding/its paired] optical emitter”** limitation in claims 1 and 14. (Pet. at 66-70.) Specifically, Petitioner relies on the embodiments shown in Imai’s Figures

10 and 11. (*Id.*) Imai's Figures 10 and 11 are reproduced below:



(EX1009, FIGS. 10-11.)

Imai fails to satisfy the “**each pixel in the plurality of pixels has a field of view coincident with an emission region of [a corresponding/its paired] optical emitter**” limitation of claims 1 and 14 under the correct construction, requiring that corresponding or paired emission and detection regions are substantially the same. (EX2009, ¶¶221-22, 224-26.) Imai discloses setting the irradiation regions of its emitters to be *larger* than the detection regions of detectors. (EX1009, [0101].) Petitioner’s position that Imai satisfies claims 1 and 14 thus depends on the view that *any* overlap between emission and detection regions is sufficient, but it is not for the reasons explained above. Ground 2 thus fails.

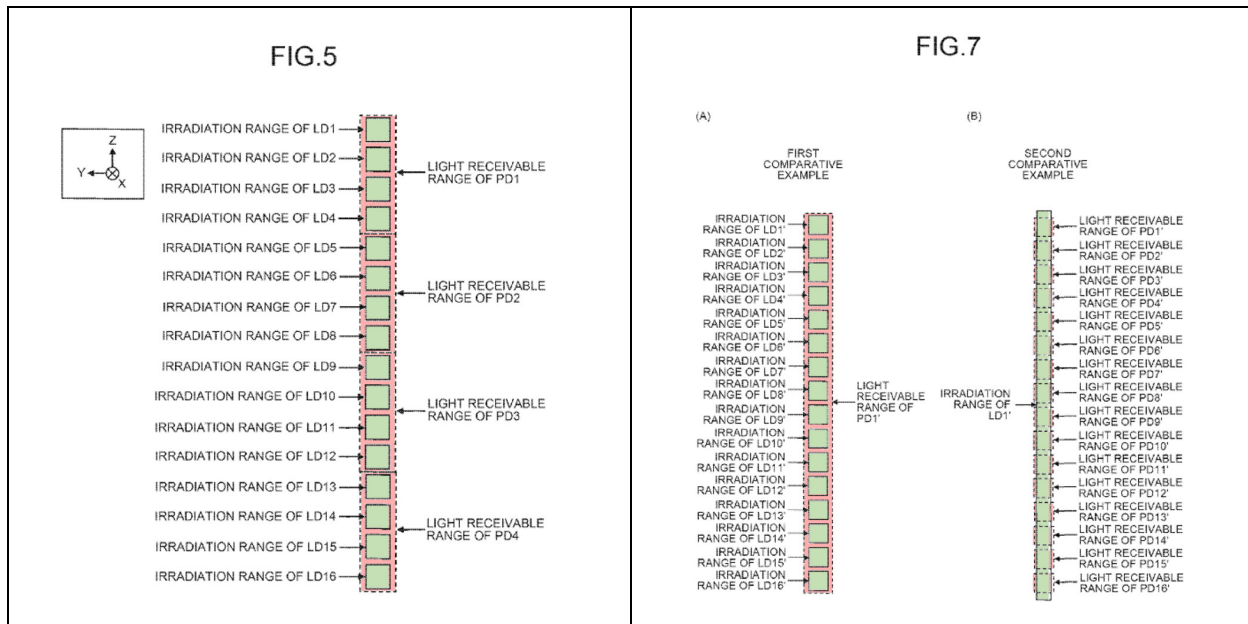
In fact, Imai makes clear that using irradiation regions that are significantly

larger than receiving ranges for its system is important to the proper functioning of its system. (EX2009, ¶223.) For example, Imai discloses:

The irradiation range of each LD is set to be slightly larger than corresponding light receiving ranges of the four PDs. According to this, it is possible to efficiently irradiate the light receivable range, so that a light reception quantity in the light receivable range may be increased and detection accuracy and a detection distance may be improved. **It is possible to inhibit deterioration in detection accuracy and detection distance even when the irradiation range and the light receivable range are slightly displaced with each other within a manufacturing range.**

(EX1009, [0101] (emphasis added).) Accordingly, a POSITA would have understood that using irradiation ranges that are significantly *larger* than the detector receiving ranges for any of Imai's embodiments was important to ensuring detection efficiency, accuracy, and distance. (EX2009, ¶223.)

Further, the use of differently sized irradiation and receiving ranges is consistently disclosed throughout Imai's embodiments. For example, Imai provides several figures indicating substantially mismatched **irradiation** and **receiving** ranges:



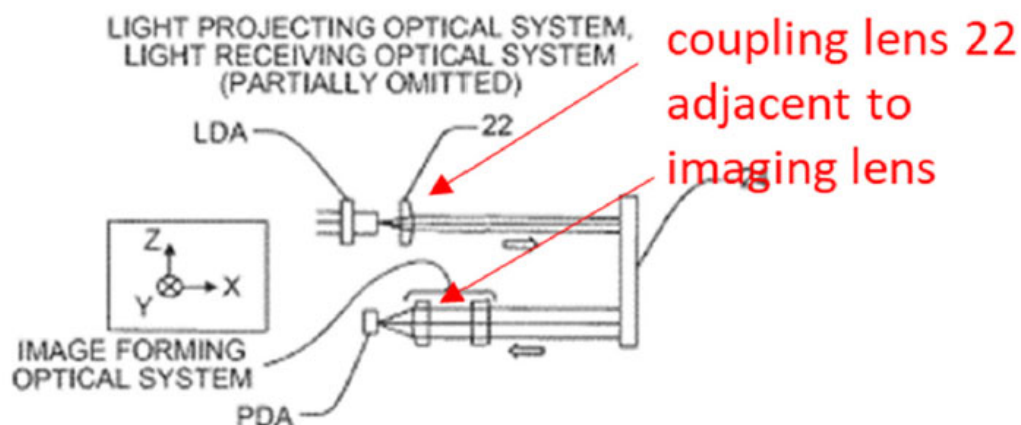
(EX2009, ¶227 (providing annotated versions of EX1009, FIGS. 5 & 7).)

Accordingly, claims 1 and 14 and the challenged dependent claims should be found not to be unpatentable over the Imai-based grounds.

2. The Imai-Based Grounds Fail to Disclose the Claimed Bulk Transmitting Optic Disposed Adjacent to the Bulk Imaging Optic

As discussed above, claim 1 recites bulk transmitting and imaging optics that are “adjacent to” each other. For the Imai-based grounds, Petitioner relies on a single figure from Imai—Figure 2C—for the “adjacent to” limitation. (Pet. at 65-66.) Petitioner asserts that “[a]s depicted in FIG. 2C . . ., coupling lens 22 of the projection optical system 20 and imaging lens on the light receiving optical system 30 are adjacent to each other along the ‘Z-axis’ direction[.]” (*Id.* at 65 (emphasis added).) Petitioner’s annotated version of Imai’s Figure 2C is reproduced below:

(C)

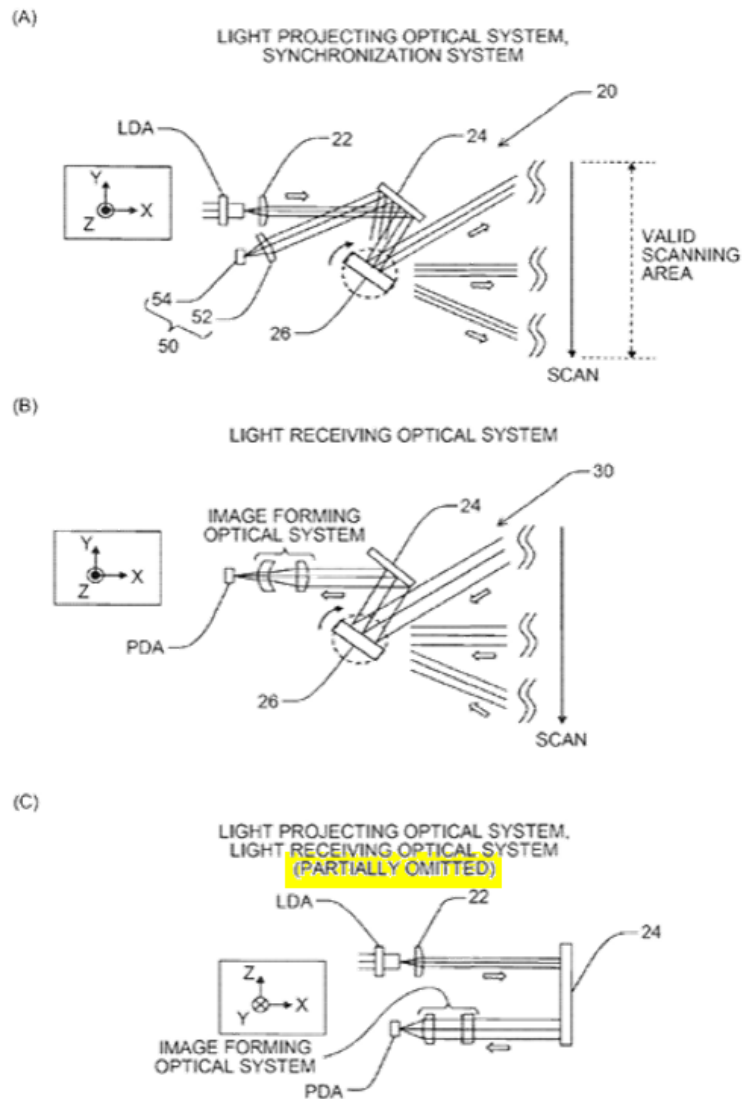


(*Id.* at 66.)

However, as Imai itself notes, the system of Imai is “partially omitted” in Figure 2C. (*Id.*) Further, Petitioner’s expert testified that Figure 2C is nothing more than a “sketch” from which “a lot” is omitted. (EX2010, 88:7-90:21.) Figure 2C does not indicate that any element is adjacent to any other element, because elements have been omitted. Petitioner’s Grounds 2A-C must fail, because Petitioner has based its entire read for the “adjacent to” limitation on a diagram that a POSITA would have understood to be incomplete as to the key question of the spatial relationships in the Imai system. (EX2009, ¶¶213-216.)

Indeed, when Figure 2C is viewed in context, it is clear that Imai does not disclose emitting and receiving optics that are adjacent. Figure 2C is in a series of three figures in Imai, where Figure 2C is the only figure that is captioned “PARTIALLY OMITTED”:

FIG.2

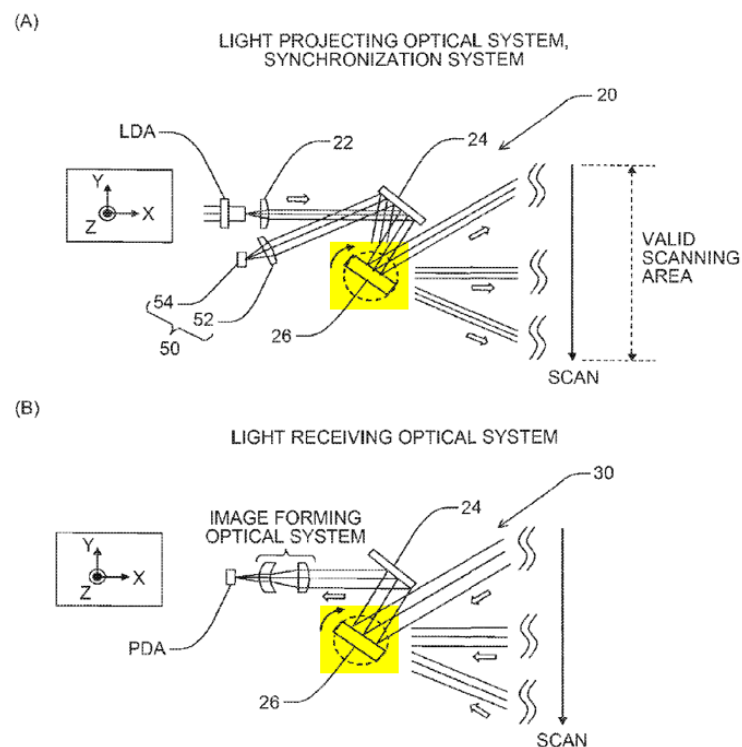


(EX1009, FIG. 2 (highlighting added).) The other two figures are presumptively complete, but they do not show lenses in the receive and transmit paths anywhere near each other. (EX2009, ¶¶213-14.) Only the “partially omitted” figure shows the various lenses—but a POSITA would not have understood an incomplete figure like this to accurately reflect spatial relationships of elements, including proximity.

(Id.)

Dr. Shanley confirmed in his testimony that Figure 2C is not an accurate representation of spatial relationships in the depicted system. Instead, Dr. Shanley testified that Figure 2C is “just a sketch basically.” (EX2010, 90:9-21.) Dr. Shanley testified that “a lot” is omitted from Figure 2C, including the elements shown in Figures 2A and 2B. (*Id.*, 88:7-90:8.)

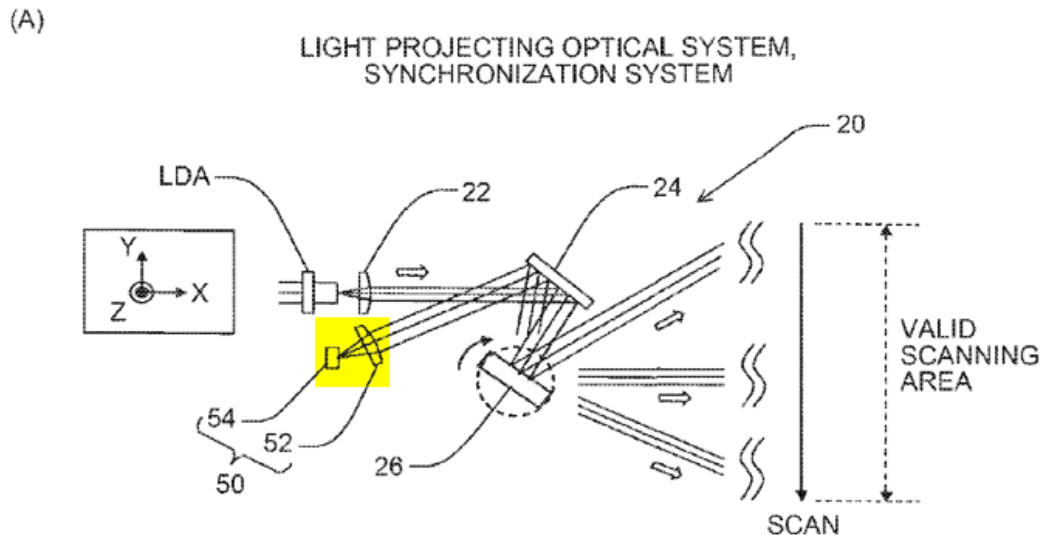
For example, Dr. Shanley testified that element **26** shown in Figures 2A and 2B is omitted from the illustration in Figure 2C. *Id.*, 89:11-90:8. Element **26** is highlighted in the reproduced Figure 2A and 2B below:



(EX2009, ¶214 (EX1009, FIGS. 2A-B (highlighting added)).)

Further, Dr. Shanley testified that “everything to the left of” element **24** in Figures 2A and 2B is omitted from the illustration shown in Figure 2C. EX2010,

90:3-8. For example, synchronization system **50** appears in Figure 2A, but is omitted from Figure 2C:



(EX1009, FIG. 2A (highlighting added).)

Given the variety of elements that are omitted from the illustration provided in Figure 2C, but which a POSITA would have understood Figure 2(C)'s system would include, Figure 2C is not a reflection of the spatial relationships a POSITA would have understood to exist in the Imai system. In relying on Figure 2(C) of Imai for Ground, Petitioner has therefore failed to provide sufficient evidence to support its contention that the “adjacent to” limitation was disclosed by the prior art.

Petitioner also generally cites to other excerpts from Imai in its petition for the “adjacent to” element. (Pet. at 60 (citing, *e.g.*, EX1009, [0038], [0039], [0041]).) However, none of these disclosures indicate that Petitioner's identified components in Imai's Figure 2C are “adjacent to” each other. (EX2009, ¶217.) Further, Dr.

Shanley testified that Imai is a “rough translation” of some unidentified underlying source and its wording is not accurate. (EX2010, 92:17.) For example, paragraph [0039] of Imai discloses that “the light projecting optical system **20** and the light receiving optical system **30** are arranged so as to be overlapped in the Z-axis direction.” (EX1009, [0039].) Petitioner generally asserts that paragraph [0039] of Imai supports that the “adjacent to” limitation is met. (Pet. at 60.) But Dr. Shanley testified that this paragraph is merely a bad translation—and that a better word for “overlapped” in Imai’s paragraph [0039] would be “coincident.” (EX2010, 95:20-97:10.) Dr. Shanley’s position on this point is frivolous; he does not claim to be fluent in Japanese and the certified translation of Imai provided by Petitioner also uses the word “overlapping,” consistent with the U.S. counterpart of Imai upon which Petitioner relies. (EX1027, at 6, [0020].)

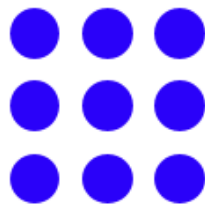
All of this confirms the fundamental fact that Imai simply does not provide clarity as to the spatial relationships between the elements it discloses. Because Petitioner has failed to provide sufficient evidence that Imai satisfies the “adjacent to” limitation of claim 1, Petitioner’s Imai-based grounds must fail as to claim 1 and its dependents.

3. Petitioner Fails to Show that the Imai-Based Grounds Disclose a “Proportional . . . Arrangement” Per Claim 3

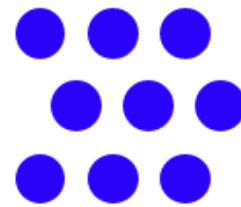
Petitioner asserts that the Imai-based grounds satisfy claim 3 of the ’381 patent based on the same improper interpretation of the claim language discussed above for

the Retterath-based grounds. (EX2009, ¶¶229-31.) Specifically, Petitioner asserts that Imai discloses using the same *number* of emitters and detectors. (Pet. at 71.)

But as discussed above for the Retterath-based grounds, having the same *number* of emitters and detectors does not indicate that the *arrangement* of emitters and detectors is proportional. Rather, as the below figure demonstrates, two collections of elements can have the same *number* of elements, but different (and non-proportional) *arrangements*.



(a)



(b)

(EX2009, ¶¶142-44.)

Accordingly, the Imai-based grounds must fail as to ground 2A—since they rely solely on the correspondence between the *number* of emitters and detectors, without showing that the *arrangement* of emitters and detectors is “proportional.” (EX2009, ¶¶229-31.)

V. SECONDARY CONSIDERATIONS OF NONOBVIOUSNESS

In addition to the arguments and evidence provided above, the patentability of the challenged '381 patent claims over the obviousness combinations asserted in each of Petitioner's grounds is supported by evidence of secondary considerations of nonobviousness. Objective evidence of secondary considerations of nonobviousness includes: (1) commercial success, (2) copying, (3) industry praise, (4) skepticism, (5) long-felt but unsolved need, and (6) failure of others. *See, e.g., Transocean Offshore Deepwater Drilling, Inc. v. Maersk Drilling USA, Inc.*, 699 F.3d 1340, 1349-56 (Fed. Cir. 2012).

A. Skepticism

The testimony of Petitioner's expert Dr. Shanley supports that there was significant industry skepticism of the use of SPADs in LIDAR systems prior to the '381 patent. (EX2009, ¶¶245-51.)

Dr. Shanley testified that while he was aware of SPADs as of the 1990s, he never incorporated them into a system, including any of the LIDAR systems he worked on. (EX2015, 12:18-22, 14:13-15:4.) For example, Dr. Shanley testified that for one LIDAR system he worked on, he specifically recalls considering using SPADs as the photodetectors in the system—but he ultimately chose to use photodiodes instead of SPADs. (*Id.*, 16:20-17:1.) Dr. Shanley testified that his team rejected SPADs because “[w]e didn’t have the volume and the power required at that point, and we wanted a simple system.” (*Id.*, 17:2-5.) Additionally, Dr. Shanley

testified that his team need a photodetector that was “very simple” and “very fast and very quick and very reliable”—and SPADs did not fit the brief. (*Id.*, 18:10-15.) Dr. Shanley testified that his team chose photodiodes instead, because they were “cheap” and an “off-the-shelf array.” (*Id.*, 17:6-12.) Shanley also testified that SPADs were incompatible with longer wavelengths of light due to semiconductor issues. (EX2010, 122:15-126:18.) In other words, Dr. Shanley testified that though he and his team knew about SPADs, they did not use SPADs in LIDAR systems due to concerns about their disadvantages, including size requirements, power requirements, complexity, cost, lack of ease of use, lack of reliability, and lack of availability. (EX2009, ¶¶245-51.) This is clear evidence that there was significant industry skepticism about the use of SPADs in a LIDAR system, which the challenged claims of the ’381 patent require.

In addition to testifying that his own team never used SPADs in a LIDAR system, Dr. Shanley testified that he was not aware of any LIDAR system, commercial or otherwise, that used SPADs before the priority date of the ’381 patent. (EX2015, 79:2-80:16.) Coupled with Dr. Shanley’s testimony that SPADs were known as of the 1990s, Dr. Shanley’s testimony about his lack of awareness of SPAD-based LIDAR systems prior to the ’381 patent provides further evidence of skepticism. Dr. Shanley’s testimony indicates that between the 1990s and 2015—a period of around 25 years—SPADs were available and known but practitioners

avoided using them in LIDAR systems. (EX2009, ¶¶245-51.) This strongly suggests that the industry harbored strong skepticism about SPADs prior to the '381 patent.

B. Failure of Others

Publications from the period before the priority date of the '381 indicate that many had sought—but failed—to develop arrays of SPADs for use in LIDAR systems. (EX2009, ¶252.) For example, Sergey L. Vinogradov, “Evaluation of performance of silicon photomultipliers in LIDAR applications” (“Vinogradov”; EX2014), which was published years *after* the September 24, 2015 priority date of the '381 patent, discusses repeated failures of researchers to develop practical SPAD arrays.

Vinogradov indicates that researchers sought to develop “front-side SPAD arrays,” but these had “a problem of a low fill factor (ratio of sensitive area to the total area occupied by electronics for active quenching of Geiger discharge)[.]” (EX2014 at 3.) Vinogradov indicates that researchers sought to eliminate the fill-factor problem by using backside illuminated SPAD technology, but “[r]egretfully,” this “introduced prohibitively high dark count rate (DCR)[.]” (*Id.*) Vinogradov indicates that another approach pursued by researchers is to use a digital SiPM (dSiPM). (*Id.* at 4.) However, Vinogradov indicates that “dSiPM technology is rather expensive and inflexible in scaling of the dSiPM dimensions and especially

in producing arrays of dSiPMs due to large periphery occupied by electronics.” (*Id.*) Having recounted the failures of these various approaches to SPAD arrays, Vinogradov concludes “[t]o the best of the author’s knowledge, there are **no attempts** either to implement SPAD arrays or dSiPMs as a single photon number resolving LIDAR receiver or to combine an array of SPAD arrays or dSiPMs as a focal plane array of photon number resolving detectors in 3D imaging LIDARs.” (*Id.* at 4 (emphasis added).)

Vinogradov shows that researchers repeatedly failed to develop SPAD arrays usable in a LIDAR system prior to the ’381 patent. Since the challenged claims all require photosensors comprised of a plurality of single photon avalanche diodes (SPADs), the failure of others that Vinogradov describes provides strong support that the challenged claims are not obvious over the prior art. (EX2009, ¶¶252-54.)

VI. CONCLUSION

Based on the arguments and evidence provided above, the Board should find claims 1-3, 5-8, and 10-17 of the ’381 patent patentable over the instituted grounds.

Dated: July 10, 2024

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CERTIFICATE OF COMPLIANCE WITH WORD COUNT

Pursuant to 37 C.F.R. § 42.24(d), I certify that this response complies with the type-volume limits of 37 C.F.R. § 42.24(a)(1)(i) because it contains 10,182 words, according to the word-processing system used to prepare this response, excluding the parts of this response that are exempted by 37 C.F.R. § 42.24(a) (including the table of contents, a table of authorities, mandatory notices, a certificate of service or this certificate word count, appendix of exhibits, and claim listings).

DATED: July 10, 2024

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CERTIFICATE OF SERVICE

I hereby certify, pursuant to 37 C.F.R. Sections 42.6 and 42.105, that a complete copy of the attached **PATENT OWNER RESPONSE**, including all exhibits (**Nos. 2009-2017**) and related documents, are being served via electronic mail on the 10th day of July 2024, upon Petitioner by serving Petitioner's counsel of record as follows:

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