

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO., LTD., SAMSUNG ELECTRONICS
AMERICA, INC., SAMSUNG SEMICONDUCTOR, INC., and SAMSUNG
AUSTIN SEMICONDUCTOR LLC,
Petitioners,

v.

W&WSENS DEVICES INC.,
Patent Owner.

Case PGR2025-00082
U.S. Patent No. 12,243,948

PATENT OWNER'S RESPONSE

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<i>In re Wands</i> , 858 F.2d 731 (Fed. Cir. 1988)	54
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PATENT OWNER'S EXHIBIT LIST

Exhibit	Description
2001	Messages between W&Wsens and Samsung (April 25, 2019 through April 26, 2019)
2002	Messages between W&Wsens and Samsung (April 27-28, 2019, August 14, 2019, February 20, 2020)
2003	Messages between W&Wsens and Samsung (April 27, 2019, August 14-15, 2019, February 20, 2020)
2004	Messages between W&Wsens and Samsung (April 24-25, 2019, May 14, 2019, August 14, 2019, March 3, 2020)
2005	W&Wsens Devices Inc. presentation – Thin Silicon Photosensors for The Next Generation
2006	Excerpts from the file history of U.S. Patent No. 10,348,240
2007	Excerpts from the file history of U.S Patent No. 10,587,095
2008	Excerpts from Plaintiff W&Wsens Devices Inc.'s Supplemental Objections and Responses to Defendants' First Set of Interrogatories (Nos. 1, 3, 4, and 5), <i>W&Wsens Devices, Inc. v. Samsung Elecs. Co.</i> , No. 24-cv-00854-JRG, E.D. Tex., served October 1, 2025
2009	Excerpts from Plaintiff W&Wsens Devices Inc.'s Objections and Responses to Defendants' First Set of Interrogatories (Nos. 1-11), <i>W&Wsens Devices, Inc. v. Samsung Elecs. Co.</i> , No. 24-cv-00854-JRG, E.D. Tex., served March 20, 2025
2010	Photon-trapping microstructures enable high-speed high-efficiency silicon photodiodes, <i>Nature Photonics</i> 11, 301-308 (2017)
2011	Order Denying Motion to Stay, <i>W&Wsens Devices, Inc. v. Samsung Elecs. Co.</i> , No. 24-cv-00854-JRG, Dkt. No. 90 (E.D. Tex. Nov. 3, 2025)

Exhibit	Description
2012	Second Amended Docket Control Order, <i>W&Wsens Devices, Inc. v. Samsung Elecs. Co.</i> , No. 24-cv-00854-JRG, Dkt. No. 54 (E.D. Tex. April 22, 2025)
2013	Order, <i>Resonant Sys., Inc. v. Sony Grp. Corp.</i> , No. 2:22-cv-00424-JRG, Dkt. No. 84 (E.D. Tex. July 9, 2024)
2014	Order, <i>Gen. Access Sols., Ltd. v. Cellco P'ship</i> , No. 2:22-cv-00394-JRG, Dkt. No. 225 (E.D. Tex. May 22, 2024)
2015	Order, <i>Cal. Inst. of Tech. v. Samsung Elecs. Co.</i> , No. 21-cv-00446-JRG, Dkt. No. 108 (E.D. Tex. Jan. 20, 2023)
2016	U.S. District Court – National Judicial Caseload Profile Federal for the Eastern District of Texas (June 2025)
2017	Excerpts from Defendants' Supplemental Invalidity Contentions cover pleading, <i>W&Wsens Devices, Inc. v. Samsung Elecs. Co.</i> , No. 24-cv-00854-JRG, E.D. Tex., served May 30, 2025
2018	U.S. Patent No. 10,622,498
2019	U.S. Patent No. 9,530,905
2020	Tech Times Webpage – Three types of photodiodes and their structure and operating principles, available at https://techtimes.dexerials.jp/en/photonics/three-types-of-photodiodes/
2021	U.S. Patent Application Publication No. 2020/0006416 (“Baba”)
2022	Excerpts from file history of U.S. Patent Application No. 16/042,535
2023	PV Education Webpage – Optical Properties of Silicon, available at https://www.pveducation.org/pvcdrom/materials/optical-properties-of-silicon#
2024	TechInsight – The state of the art of CMOS Image Sensors, by Ziad Shukri, presented at IISW 2021

Exhibit	Description
2025	Excerpts from “Introduction to Solid State Physics,” by Charles Kittel (7th ed. 1996)
2026	U.S. Patent Application Publication No. 2011/0309331 (“Yu-331”)
2027	U.S. Patent Application Publication No. 2014/0016660 (“Lunev”)
2028	Intentionally Omitted
2029	Excerpts from “Electrical Engineering Dictionary,” by Phillip. A. Laplante, CRC Press LLC 2000
2030	PatDocs Machine Translation of JP3423279B2 to Hiramoto
2031	Wikipedia webpage, “Beer-Lambert law” available at https://en.wikipedia.org/wiki/Beer-Lambert_law , dated October 8, 2025
2032	“Understanding the Limits of the Bouguer-Beer-Lambert Law,” by T. Mayerhöfer, et al., Spectroscopyonline, available at https://www.spectroscopyonline.com/view/understanding-the-limits-of-the-bouguer-beer-lambert-law , dated 2023-2024
2033	JP3423279B2 to Hiramoto
2034	Excerpts from file history of U.S. Patent Application No. 19/036,506 (the “’947 Divisional”) from Sept. 16, 2025 to Nov. 21, 2025
2035	U.S. Provisional Application 61/826,446 filed May 22, 2013
2036	Excerpts from ’871 Patent File History
2037	FPO IP Research & Communities – Search string of Ex. 1091 modified to remove “vertical” condition, available at https://www.freepatentsonline.com/search.html , dated December 12, 2025
2038	FPO IP Research & Communities - Search results of query in Exhibit 2037, dated December 12, 2025

Exhibit	Description
2039	Declaration of Dr. Brian W. D'Andrade, Ph.D. in Support of Patent Owner's Response
2040	Order Denying Request for Ex Parte Reexamination of U.S. Patent No. 12,087,871, Case No. 90/016,025 (Apr. 27, 2026)
2041	Order Denying Request for Ex Parte Reexamination of U.S. Patent No. 11,621,360, Case No. 90/015,962 (Apr. 20, 2026)
2042	Declaration of Dr. Michael Lebby in Support of Request for Ex Parte Reexamination of U.S. Patent No. 12,087,871, Case No. 90/016,025 (Mar. 5, 2026)
2043	Intentionally Omitted
2044	General Order on "Related Matters Updates," Deshpande, Patent Trial and Appeal Board (Sept. 16, 2025)
2045	U.S. Patent No. 12,087,871
2046	Joint Claim Construction Chart, <i>W&Wsens Devices, Inc. v. Samsung Elecs. Co.</i> , No. 24-cv-00854-JRG, Dkt. Nos. 111, 111-1 (E.D. Tex. Jan. 20, 2026)
2047	Joint Claim Construction and Prehearing Statement, <i>W&Wsens Devices, Inc. v. Samsung Elecs. Co.</i> , No. 24-cv-00854-JRG, Dkt. No. 92 (E.D. Tex. Nov. 12, 2025)
2048	Deposition Transcript of Dr. Michael Lebby in <i>Samsung Elecs. Co. v. W&Wsens Devices, Inc.</i> , No. PGR2025-00082, taken on May 5, 2026
2049	University of Cambridge webpage, "Organic Semiconductors," Optoelectronics Group, available at https://www.oe.phy.cam.ac.uk/research/materials/osemiconductors , produced in <i>W&Wsens Devices, Inc. v. Samsung Elecs. Co.</i> , No. 24-cv-00854-JRG with bates numbers WWSSENS 603454-59

Exhibit	Description
2050	Excerpts from “ <i>Fundamentals of Semiconductors: Physics and Materials Properties</i> ,” by Peter Y. Yu and Manuel Cardona (4th ed. 2010), produced in <i>W&Wsens Devices, Inc. v. Samsung Elecs. Co.</i> , No. 24-cv-00854-JRG with bates numbers WWSSENS 603439-53
2051	Excerpts from “ <i>Electronic Processes in Organic Semiconductors: An Introduction</i> ,” by Anna Köhler and Heinz Bässler, Wiley-VCH, produced in <i>W&Wsens Devices, Inc. v. Samsung Elecs. Co.</i> , No. 24-cv-00854-JRG with bates numbers WWSSENS 603478-84
2052	U.S. Patent No. 9,666,817
2053	U.S. Patent No. 9,673,258
2054	Article Metrics for “Photon-trapping microstructures enable high-speed high-efficiency silicon photodiodes,” Nature Photonics, available at https://www.nature.com/articles/nphoton.2017.37/metrics , produced in <i>W&Wsens Devices, Inc. v. Samsung Elecs. Co.</i> , No. 24-cv-00854-JRG with bates numbers WWSSENS 603395-96

I. INTRODUCTION

The Board should confirm the patentability of the Challenged Claims of U.S. Patent No. 12,243,948 (Ex. 1001, “the ’948 Patent”) because Ex. 1004 (“Kuboi”), Ex. 1005 (“Vasylyev”), and Ex. 1006 (“Shinohara”), alone or in combination, do not disclose the core structural features of the claimed photodetector.

Kuboi takes an altogether different approach to photodetection than the ’948 Patent teaches and claims. The ’948 Patent is directed to using microstructures, such as in-pillar holes, to enhance the light absorption of silicon-based photodetectors. In contrast, Kuboi replaces the inorganic photodetecting silicon with an organic photoelectric conversion material, while deliberately shielding the surrounding silicon from light to prevent photoconversion therein. In Kuboi’s device, the silicon surrounding the organic material only transports charge carriers that the organic material has generated. Kuboi at [0011], [0057], [0059], [0064].

The Patent Office has already weighed and rejected the same invalidity theory that Petitioners press here. Petitioners recently filed an *ex parte* reexamination (“EPR”) of the ’948 Patent’s immediate parent, U.S. Patent No. 12,087,871 (“the ’871 Patent”), a patent which shares the same disclosure and similar claims as the ’948 Patent. But, the Office denied the reexamination request after finding no “substantial new question of patentability.” Ex. 2040 (“the ’871 EPR”) at 8, 10. Petitioners’ EPR request was supported by the same expert (Dr. Lebby), relied on

the same primary reference (Kuboi), and advanced the same structural mappings that Petitioners now deploy in this proceeding. The Examiner correctly found that Kuboi's pixels are not the claimed pillars with light-receiving surfaces configured to generate electrical charge carriers, that Kuboi's openings are not holes filled with solid dielectric material, and that Kuboi does not satisfy the claimed 1.1x absorption enhancement. *Id.* at 7. As discussed in detail in Section III.C below, the Office's findings on the '871 Patent's parallel claim limitations directly undercut Petitioners' case against the Challenged Claims, and Petitioners have offered no persuasive reason to reach a different result here.

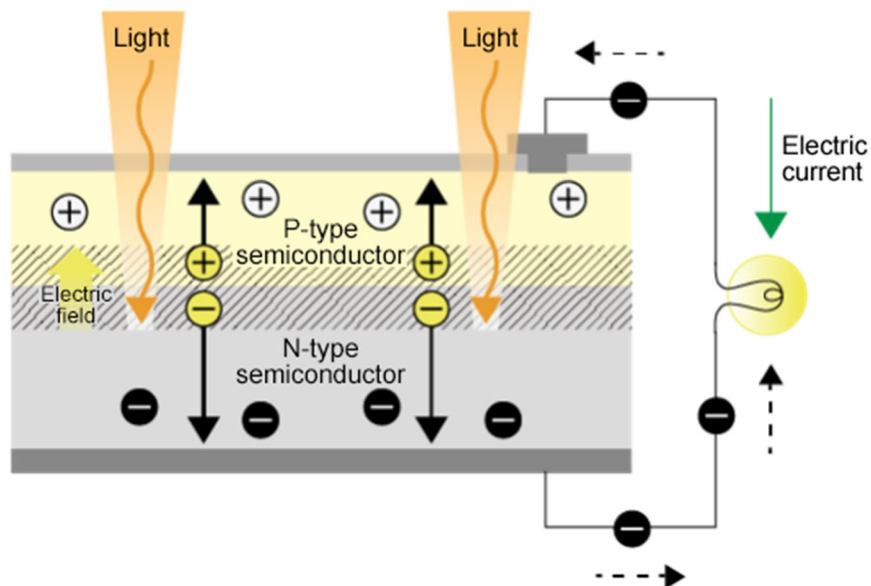
Petitioners' enablement challenge under § 112 is equally without merit, because the specification and intrinsic record of the '948 Patent fully enable a person of ordinary skill in the art to practice the claimed invention without undue experiment. The Office already reached this conclusion in the context of a divisional of the '948 Patent.

For these reasons, and as set forth in detail below, Petitioners fail to demonstrate by a preponderance of the evidence that any Challenged Claim of the '948 Patent is unpatentable. The Board should uphold the validity of Claims 1-16.

II. TECHNOLOGY OVERVIEW

A. Photodetectors Convert Light into Electrical Signals

Photodetectors are devices that convert light into electrical signals by absorbing photons and generating mobile electrical (charge) carriers. Ex. 2020 at 2. A photodetector may include one or more photodiodes, which are light-sensitive semiconductor diodes that convert incoming photons into electrical charges. Ex. 2039 (“D’Andrade Decl.”) at ¶¶ 47-49.



Ex. 2020 at 4 (showing schematic of photodiode structure).

A photodetector can be characterized by its quantum efficiency, which is the ratio of the number of charge carriers generated and successfully collected to the number of incident photons on the device. See Ex. 1028 at 25 (“[Q]uantum efficiency η is defined as the number of photogenerated electron–hole pairs, which contribute to the photocurrent, divided by the number of the incident photons.”).

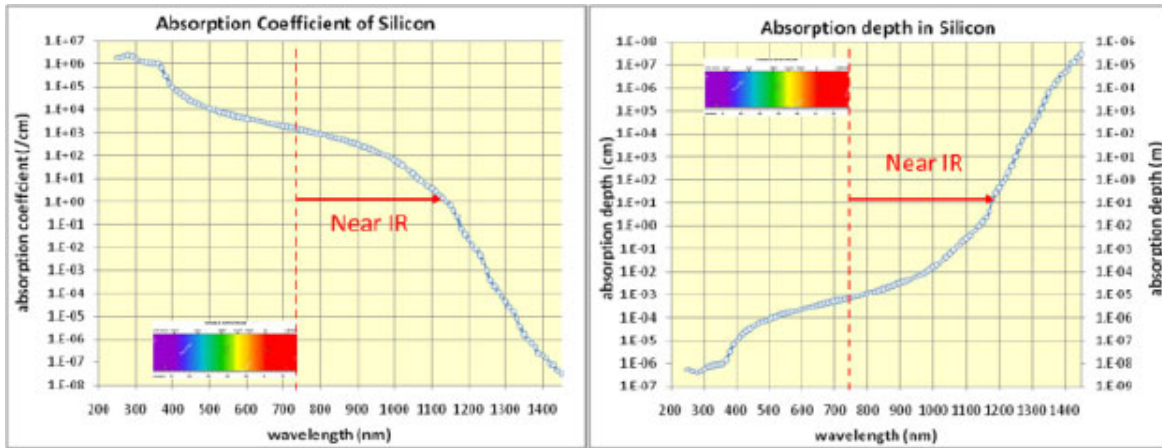
Quantum efficiency is a key performance parameter because it directly determines how effectively the photodetector converts incident optical power into an electrical signal. High quantum efficiency improves signal strength and signal to noise ratio, which is especially critical in low-light conditions where photon flux is limited, and photodetector performance is often constrained by noise.

Photodetectors are commonly found in smartphone cameras. Many of today's digital cameras use Complementary Metal-Oxide-Semiconductor "CMOS" sensors to convert light into digital image data. CMOS chips are integrated circuits built using complementary arrangements of p-type and n-type MOSFETs to process the charge carriers. CMOS technology broadly refers to the methods and techniques used to make CMOS chips. In CMOS sensors, arrays of photodiodes or pixel structures are fabricated directly on a CMOS chip. They detect light by absorbing photons and generating electrical charges in response to the light intensity (or the total number of photons impinging on the sensor). The resulting electrical signal is then amplified and processed by on-chip transistors. The cells of CMOS sensors are generally made from semiconducting silicon.

B. Silicon Absorbs Red and Infrared Light Poorly

Digital cameras often rely on silicon photodetectors because of advantages such as low cost and mature manufacturing processes. One downside of using silicon is that its absorption coefficient varies dramatically as a function of

wavelength, with absorption dropping off considerably as the wavelength of light approaches the red and infrared portions of the spectrum:



Ex. 2023 at 2-3 (annotations added) (illustrating silicon's decreasing ability to absorb longer wavelength light). In essence, silicon is relatively transparent to red and infrared light; therefore, long-wavelength light (red to infrared) is not absorbed efficiently due to silicon's indirect bandgap structure. *Id.*; '948 Patent at 2:4-7. For this reason, traditional silicon-based photodetectors struggled to achieve acceptable quantum efficiency and image quality in certain conditions, such as in dim light. D'Andrade Decl. at ¶ 50.

C. Conventional Solutions Suffered from a Tradeoff Between Absorption and Bandwidth

One conventional solution to silicon's inability to absorb relatively long wavelength light was simply to increase the thickness of the silicon photodetector. '948 Patent at 2:7-16; *see* D'Andrade Decl. at ¶¶ 51-55. With a thick photodetector, incident light passes through more silicon, leading to greater absorption. For

wavelengths longer than 730nm, the photoconverting portion of the Si would need to be at least 10 μ m thick to absorb only 64% of the incident light. Ex. 2023 at 2-3.

The need for thick silicon layers presented several problems for the industry. For example, thicker devices were ill-suited for telecommunications applications due to their relatively low bandwidth: because it takes longer for photo-generated carriers to drift or diffuse to electrical contacts, thicker devices limit how quickly the photodetector can respond to an optical input. *See* '948 Patent at 2:7-18. Thicker devices are also less suitable for use in applications where pixels are tightly packed, such as in smartphone cameras.

It is also more difficult and expensive to manufacture relatively thick devices, which leads to lower fabrication yields and increased costs. CMOS sensor designers have been increasing pixel count and shrinking individual pixel size to yield higher resolution images. As the distance between adjacent pixel centers—the pixel pitch—decreases, chip designers have been increasing the active silicon thickness of the photodiode region to preserve light absorption and maintain image quality.

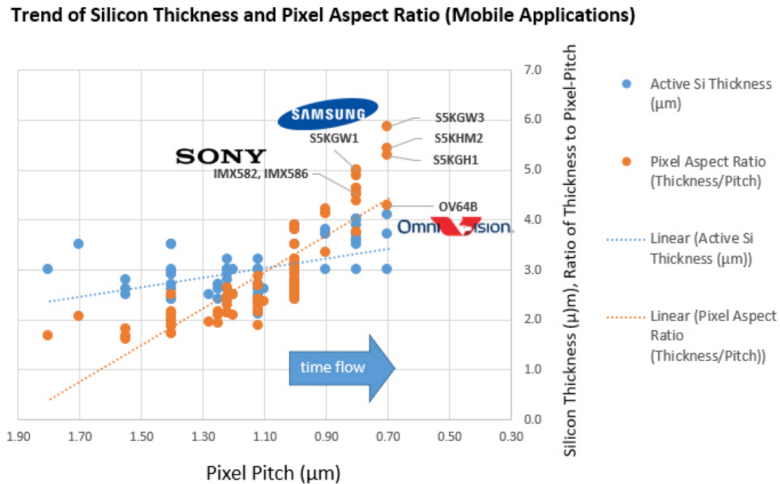


Figure 3 Trend of silicon thickness to pixel pitch ratio.

Ex. 2024 at 8, Fig. 3 (showing the trend of decreasing pixel pitch and increasing active silicon thickness over time).

However, fabricating relatively thick silicon devices while decreasing pixel size led to difficulties, including lower yield and increased costs for the CMOS sensors. Further reduction in pixel size requires thinning the absorption region, but thinning this region reduces detection efficiency, especially for light in the red to infrared part of the spectrum. Although there are materials with better absorption properties than Si, including direct-bandgap materials like indium gallium arsenide (InGaAs), those materials are relatively expensive and can have high multiplication noise when compared with silicon. '948 Patent at 2:19-31. Accordingly, for many applications, Si-based photodetectors are the only real option. Ex. 1028 at 7 (“Silicon photodetectors and receiver OEICs, therefore, are the only choice when

high volumes are needed and the price has to be low as, for instance, in consumer electronics.”).

Thus, there was a need to improve the efficiency of silicon photodetectors to solve these problems and allow for smaller and thinner pixels that could efficiently capture enough light to generate high quality images. '948 Patent at 1:61-2:31, 8:17-36.

III. OVERVIEW OF THE '948 PATENT

A. The '948 Patent Uses Microstructures to Increase the Sensitivity of Thin-Silicon Photodetectors

To overcome limitations of conventional silicon CMOS sensors, W&Wsens' inventions use microstructures in the surface of pillars formed of light-sensitive silicon photodetectors. These microstructures, including in-pillar holes and pillar side-isolation, improve the silicon's sensitivity without the need for a thick absorption layer, which results in telecommunications bandwidths over 10 Gb/s for 850 nm wavelength light and photodetector quantum efficiencies exceeding 90%. '948 Patent at Abstract, 10:13-23, 10:60-67, 11:45-51, 15:26-35.

This result is counterintuitive because the presence of holes reduces the amount of photosensitive silicon material available to absorb incident light, which would have been expected to reduce light absorption. Yet the '948 Patent's photodetector device enhances the effective absorption length of the thin silicon because the microstructures cause light to interact with the absorbing silicon layers

for a longer length of time, which the industry previously achieved by using a thick silicon layer. *Id.* at 8:17-36, 9:4-14.

To capitalize on this invention, the '948 Patent claims “an integrated structure,” such as the “high-speed high efficiency microstructured photodiode 520” of Fig. 5B, which has “an array of pillars” that are side-isolated and have “one or more holes that are fabricated as recesses at or under the light-receiving surface of each of at least some of the pillars,” an example of which is depicted in Fig. 49 reproduced below:

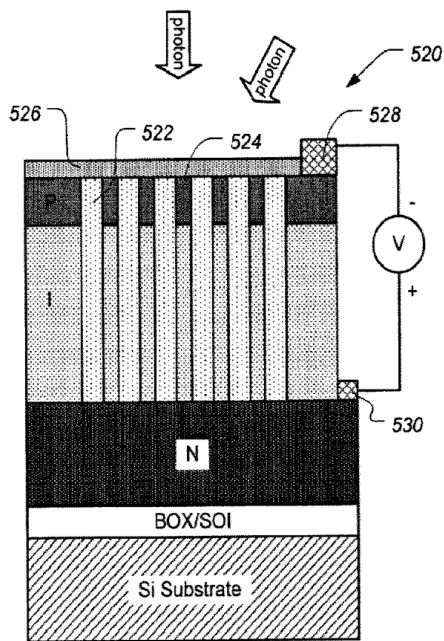


FIG. 5B

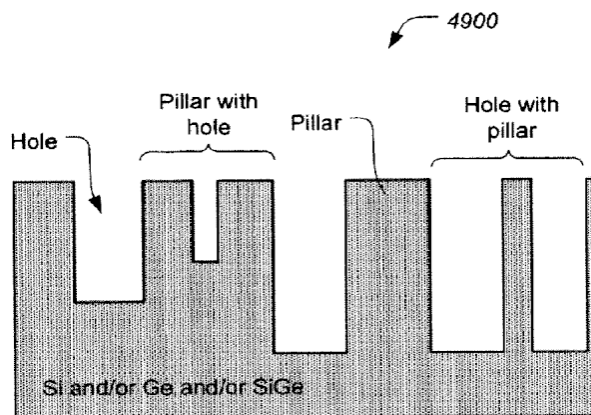


FIG. 49

'948 Patent, Fig. 5B; *see id.* at 55:38-43 (Claim 1), 16:9-59 (explaining embodiment in Fig. 5B), 55:48-53 (Claim 1), Fig. 49 (depicting an example “Pillar with hole”); *see also id.* at 49:52-50:33 (describing microstructured surface of Fig. 49).

This novel structure and arrangement of in-pillar holes results in a marked increase in light absorption compared to other photodetectors lacking these in-pillar holes. *Id.* at 55:64-67 (claims reciting “presence of said [] holes increase[] by a factor of at least 1.1 the absorption of the light by [] the photodetectors relative to like photodetectors lacking said holes”); D’Andrade Decl. at ¶¶ 74-77, 78-79.

The inventors of the ’948 Patent disclosed its microstructure technology in a peer-reviewed research paper published in the *Nature Photonics* journal, which a POSITA would understand is a noteworthy achievement signaling the importance and major impact of the research on the field. *See* Ex. 2010; D’Andrade Decl. at ¶¶ 76-77.

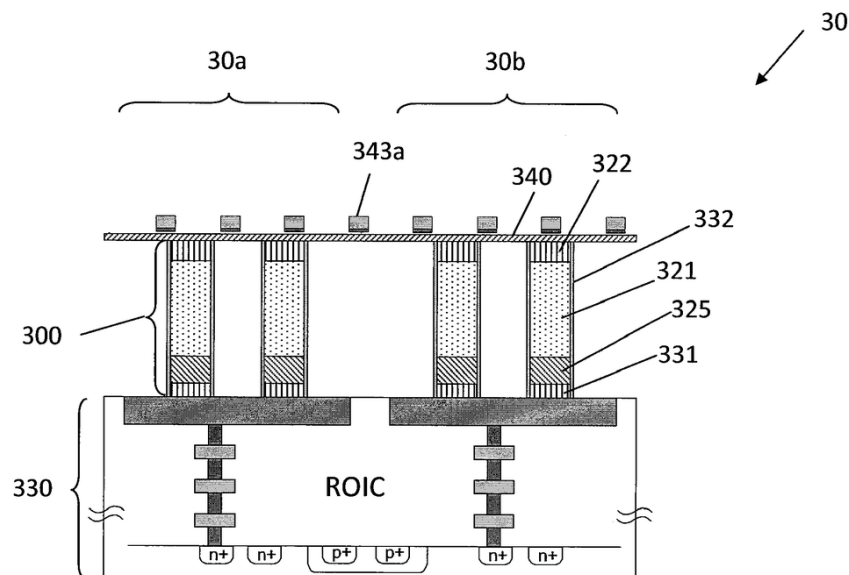
B. The Examiner Found That the Prior Art Lacks In-Pillar Holes in Side-Insulated Pillars

The Examiner explained in the ’948 Patent’s Reasons for Allowance that the prior art lacked the required in-pillar holes that improved absorption by a factor of at least 1.1:

Regarding claim 1, the prior art of Yu et al. (US 2011/0309331) discloses in Fig. 5 and Lunev et al. (US 2014/0016660) discloses in Fig. 4B, pillar shaped photodetector devices, but *fails to disclose the specific characteristic recited in the claims of the instant invention* e.g. the combination of claimed features of *an array of pillars* with particular material composition and NP junction sensitive to visible and infrared wavelengths, *one or more holes* that are fabricated as recesses

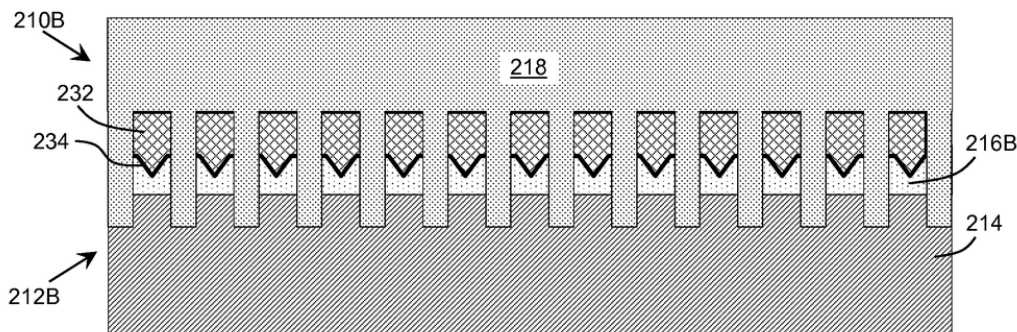
wherein at least some of the holes are elongated along the respective light receiving surfaces, side isolation, solid dielectric forming base dielectric, electrical contacts and the presence of the holes increase absorption by a specific amount.

Ex. 1003 at 22-23 (emphasis added); *id.* (finding now-issued Challenged Claim 13 allowable for similar reasons); *id.* at 22 (“[P]illar shaped photodetector device as recited in the claims of the instant invention fail to be taught by the prior art cited of interest.”). The Examiner cited Fig. 5 of Yu-331 (Ex. 2026) (reproduced below) as disclosing “pillar shaped photodetector devices,” but found that Yu-331 fails to disclose, among other elements, the presence of the claimed in-pillar holes that increase absorption by at least 1.1x:



Ex. 1003 at 22; Ex. 2026 (Yu-331), Fig. 5. The Examiner also cited Fig. 4B of Lunev (Ex. 2027) (reproduced below) as disclosing “pillar shaped photodetector devices,” but found that Lunev similarly does not disclose in-pillar holes that increase absorption.

FIG. 4B



Ex. 1003 at 22; Ex. 2027 (Lunev), Fig. 4B.

During prosecution, the Examiner identified certain prior art as having “similar structures depicting the state of the art at the time of the invention” but found that these references did not have sufficient disclosure to invalidate the Challenged Claims. Ex. 1003 at 296-298. For example, the Examiner cited a vertical pillar structured photovoltaic device disclosed in U.S. Patent No. 9,515,218 to Yu as having similar but distinguishable structures as the then-pending '948 claims.

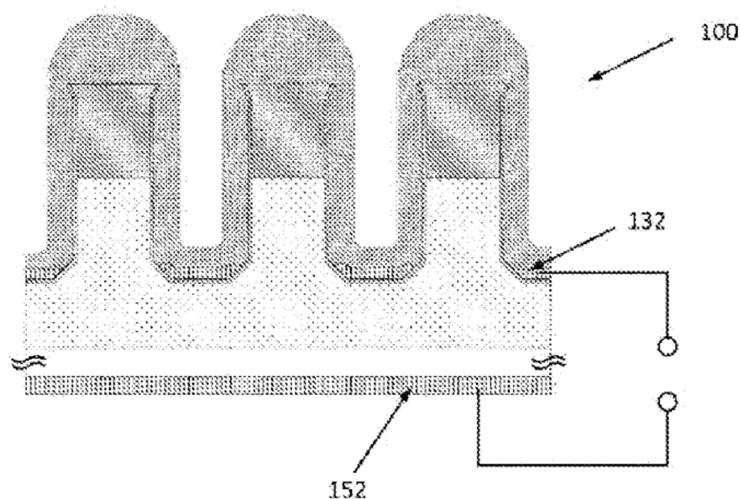
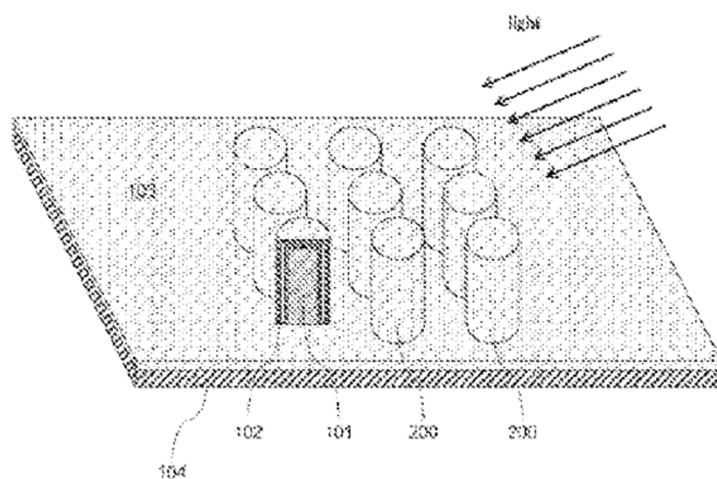


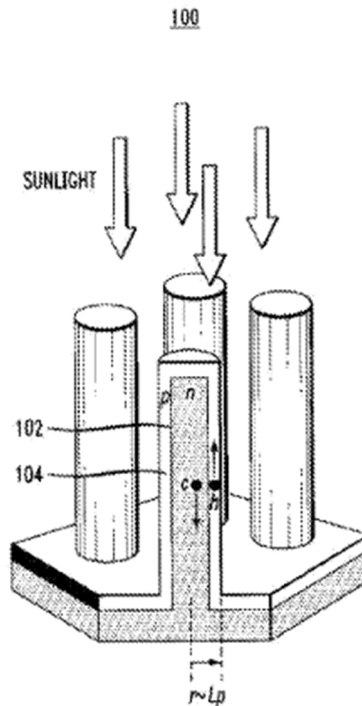
Fig. 8A

Id. at 296 (citing U.S. Pat. No. 9,515,218 to Yu et al., Fig. 8A). In another example, the Examiner cited to a nanopillar tunneling photovoltaic cell disclosed in U.S. Patent Publication No. 2013/0125965 to Hazeghi *et al.*, reproduced below, as having structures distinguishable from the then-pending '948 Patent claims.



Ex. 1003 at 296 (citing U.S. Patent Pub. No. 2013/0125965 to Hazeghi et al., Fig. 1). Lastly, the Examiner cited to techniques for fabricating nanowire and microwire-

based solar cells, disclosed in U.S. Patent Publication No. 2012/0196401 to Graham, reproduced below, but found that, like the other references, it did not disclose the claimed structures.



Ex. 1003 at 297 (citing U.S. Patent Pub. No. 2012/0196401 to Graham et al., Fig. 1).

Thus, the Examiner repeatedly distinguished the '948 Patent over the prior art for the Claims' specific recitations of an "array of pillars" with side isolation, "one or more holes that are fabricated as recesses at or under the light-receiving surfaces of . . . some of the pillars," or the holes enhancing light absorption by a specific amount. As set forth below, Petitioners' asserted references in this PGR also lack these key features. D'Andrade Decl. at ¶¶ 80-86.

C. The Patent Office Recently Confirmed Kuboi Does Not Teach In-Pillar Holes and Side-Isolation in the '871 Patent EPR

Despite repeated attempts by Petitioners, the Patent Office recently confirmed the validity of related W&Wsens patents, including the '871 Patent and U.S. Patent No. 11,621,360 (“the '360 Patent”), which are the '948 Patent’s parent and grandparent, respectively. Specifically, in November 2025, the Office denied institution of IPR2025-00993 and IPR2025-00994 challenging the '871 Patent and '360 Patent based on a review of discretionary considerations. *See* Case No. IPR2025-00993, Paper 14 (P.T.A.B. Nov. 20, 2025).

Petitioners then filed requests for ex parte reexamination of the '871 Patent, '360 Patent, and others in March and February 2026.¹ In the case of the '871 Patent,

¹ Petitioners failed to notify the Board of its filing of ex parte reexamination of the related W&Wsens patents, and the subsequent denials of those ex parte reexamination requests. Counsel for W&Wsens did not become aware of the ex parte reexamination filings until April 29, 2026. Petitioners’ failure to update the Board violates Acting Chief Administrative Patent Judge Deshpande’s “Related Matters Updates” General Order dated September 16, 2025, requiring parties to keep the Board “apprised of developments regarding adjudication of validity or patentability of the challenged patent claims, or substantially similar patent claims, . . . in ‘any other judicial or administrative matter that would affect, or be affected

the EPR request repeated Petitioners' invalidity challenge from IPR2025-00993, using Kuboi, Shinohara, and Yu (Ex. 1025). The '360 Patent's EPR challenge was a similar re-hash. And the Office denied the EPR requests and found there was no "substantial new question of patentability" in substantive, merits-based rejection of essentially the same prior-art challenge presented in this case. *See generally* Ex. 2040 ('871 EPR); Ex. 2041 ('360 EPR). Taken together with the outcome of the '871 EPR, the Office has now rejected the Petitioners' challenge of the related '871 Patent on both discretionary considerations and the merits and substance.²

Claims 1 and 13 of the '948 Patent recite "an array of pillars," "wherein at least some of the pillars are configured to include photodetectors and have respective light-receiving surfaces" and "are configured to respond to illumination with light

by, a decision in the proceeding' and is identified as a related matter under 37 C.F.R. § 42.8(b)(2)." *See* General Order, Ex. 2044 at 1; *see also* Paper 18 (Scheduling Order) at 2. Petitioners identified the other W&Wsens patents as "Related Matters" in its Mandatory notice, yet still failed to notify the Board of these developments regarding the related W&Wsens patents. *See* Pet. at 143.

² Petitioners filed two other reexamination requests, in Control Nos. 90/015,944 (challenging U.S. Patent No. 10,446,700) and 90/015,945 (challenging U.S. Patent No. 10,468,543). Reexaminations were ordered in those cases on April 20, 2026.

in selected visible and infrared wavelengths by generating electrical charge carriers,” and “one or more holes formed as recesses at or under the light-receiving surface of each of at least some of the pillars . . . filled at least partly with solid dielectric material,” and where “the presence of said . . . holes increases by a factor of at least 1.1 the absorption of the light.” ’948 Patent at 55:37-67, 56:43-57:11.

Corresponding and similar limitations are found in the ’871 Patent, which the Office found Kuboi incapable of teaching (in the ’871 EPR). Ex. 2045 (’871 Patent) at 55:42-67. A comparison of relevant claim limitations between the ’948 Patent and ’871 Patent is provided below.

’948 Patent Claim 1 Limitation	’871 Patent Claim 1 Limitation (Ex. 2045)
[1a(1)]: “an array of pillars comprising Si, Ge, and/or SiGe alloy semiconductor material,”	“an array of pillars comprising Si, Ge, and/or SiGe alloy semiconductor material”
[1a(2)]: “wherein at least some of the pillars are configured to include photodetectors and have respective light-receiving surfaces and respective sides;”	“wherein at least some of the pillars are configured as photodetectors that have respective light-receiving surfaces and have sides”
[1b]: “wherein at least some of the pillars ... are configured to respond to	“wherein at least some of the photodetectors ... are configured to

illumination with light in selected visible and infrared wavelengths by generating electrical charge carriers;”	respond to illumination with light in selected visible and infrared wavelength ranges by generating electrical charge carriers”
[1c]: “one or more holes that are fabricated as recesses at or under the light-receiving surface ... and are filled at least partly with solid dielectric material;”	“one or more holes that are deliberately formed into the light-receiving surfaces, ... are filled at least partly with solid dielectric material;”
[1h]: “wherein the presence of said one or more holes increases by a factor of at least 1.1 the absorption of the light by at least some of the photodetectors relative to like photodetectors lacking said holes.”	“wherein the presence of said one or more holes increases by a factor of at least 1.1 the absorption of the light by at least some of the photodetectors relative to otherwise like photodetectors lacking said holes.”

The '871 EPR was supported by a declaration from Dr. Lebby, the same expert whose opinions underlie Petitioners' invalidity case in this PGR proceeding. *See* Ex. 2042 (Lebby EPR Decl.). The Office stated that it “fully considered” the Lebby EPR Declaration “as to its explanation of the contents of the prior art references cited in the Request.” Ex. 2040 ('871 EPR) at 2. Dr. Lebby's EPR Declaration mapped Kuboi's etched “vertical holes 38,” filled with organic

photoelectric conversion film, to the claimed “holes that are deliberately formed into the light-receiving surfaces.” Ex. 2042 (Lebby EPR Decl.) at ¶¶ 120-121. Dr. Lebby further mapped Kuboi’s pixels to the claimed “array of pillars ... configured as photodetectors that have respective light-receiving surfaces and have sides.” *Id.* at ¶ 105. In short, Dr. Lebby presented to the Office the very prior-art mapping he now brings to this proceeding. The Office rejected it.

The Office’s findings were direct and dispositive. The Office considered the merits of Petitioners’ argument, stating “Kuboi teaches, among other things, elements 38 as shown in Figure 4B that are ‘holes’ at least in the sense that they are negative spaces formed in the semiconductor layer 12.” Ex. 2040 (’871 EPR) at 7. And then the Office found “Kuboi does not teach pillars that are configured as photodetectors that have respective light-receiving surfaces and are configured to respond to illumination with light in selected visible and infrared wavelength ranges by generating electrical charge carriers” and “one or more holes that are deliberately formed into the light-receiving surfaces and are filled at least partly with solid dielectric material,” as recited in claim 1 of the ’871 Patent. *Id.*

The Office reasoned “[e]ven if for the sake of argument Kuboi teaches ‘pillars’ comprising the remaining sections of semiconductor layer 12 that are not removed in holes 38, holes 38 are not deliberately formed into the light-receiving surfaces of the pillars and holes 38 have organic photoelectric conversion film 13

therein (not solid dielectric)” Ex. 2040 (’871 EPR) at 7 (citing Kuboi, Figures 1A and 6A; paragraphs [0064] and [0091]-[0093]). The Office also found that “[t]he remaining sections of semiconductor layer 12 are not pillars that have respective light-receiving surfaces and are configured to respond to illumination with light in selected visible and infrared wavelength ranges by generating electrical charge carriers as recited in claim 1 [of the ’871 Patent]” because the remaining sections of semiconductor layer 12 are shielded from light (by light shielding film 19) such that “light photons would be incident on the organic photoelectric conversion film 13 in holes 38, not the semiconductor layer 12.” *Id.* (citing Kuboi, Figures 1A and 4F, paragraphs [0064] and [0076]). The Office further concluded that because Kuboi failed to teach “holes in the way recited in claim 1,” Kuboi also could not teach the claimed increase in light absorption by a factor of 1.1x due to the presence of the holes. *Id.*

The Office’s findings in the reexamination decision for the parent ’871 Patent and grandparent ’360 Patent support the validity of the challenged ’948 Patent and confirm that Petitioners’ invalidity theory rests on a prior-art mapping the Patent Office has already considered and rejected. D’Andrade Decl. at ¶¶ 87-93.

IV. PETITIONERS' CHALLENGE AND THE ASSERTED REFERENCES

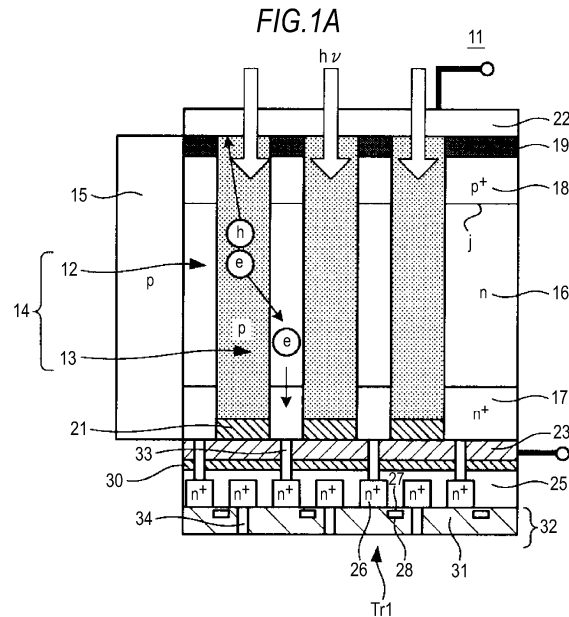
The Petition presents the following grounds:

Ground	Claims	35 U.S.C.	References/Details
1	1-3 and 7-12	§ 103	Kuboi
2	4-6 and 13-16	§ 103	Kuboi and Vasylyev
3	1-3 and 7-12	§ 103	Kuboi and Shinohara
4	4-6 and 13-16	§ 103	Kuboi, Vasylyev, and Shinohara
5	1-16	§ 112	Lack of Enablement

Pet. at 8.

A. Kuboi Does Not Disclose a Microstructure-Enhanced Photodetector Device

Kuboi does not disclose an integrated structure enhanced by microstructures, such as pillars and holes, as recited in the Challenged Claims. Kuboi discloses a “solid-state imaging device” that includes photodetectors with a “hybrid photoelectric conversion portion 14” having “organic material layers 13” embedded in a silicon “semiconductor layer 12.” Kuboi at [0001], [0055]; D’Andrade Decl. at ¶¶ 94-95.

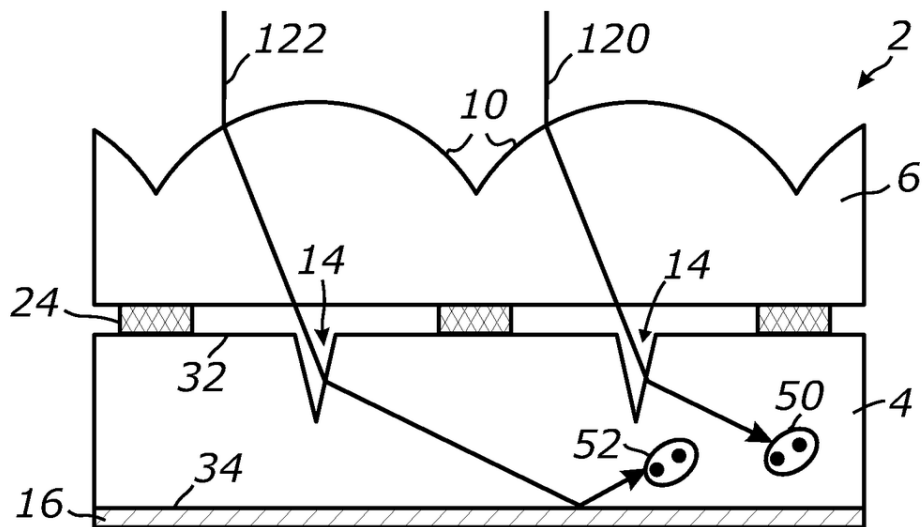


Id., Fig. 1A (showing Kuboi’s hybrid structure).

Unlike the photon-absorbing, silicon/germanium-based image sensors claimed in the '948 Patent, Kuboi's imaging device is configured so that "[t]he organic material layer 13 is [the] region where photoelectric conversion is performed," rather than its silicon semiconductor layer 12. Kuboi at [0057]. Accordingly, for reasons described in greater detail below, Kuboi does not disclose a microstructure enhanced photodetector device that absorbs light in pillars of Si, Ge, or a SiGe alloy, because it does not utilize any types of microstructures, such as an "array of pillars" or "one or more holes that are fabricated as recesses at or under the light-receiving surface . . . of the pillars," to enhance its imaging device. D'Andrade Decl. at ¶ 96.

B. Vasylyev Does Not Disclose Pillars or In-Pillar Holes

Vasylyev does not disclose side-isolated pillars with in-pillar holes (i.e., “one or more holes that are fabricated as recesses at or under the light-receiving surface of each of at least some of the pillars”). Vasylyev is limited to a “light harvesting system” in which “[l]ight is injected into a photoresponsive layer through light input ports using a focusing array.” Vasylyev at [0015]-[0016]; D’Andrade Decl. at ¶¶ 97-98.



Vasylyev, Fig. 11 (showing light input ports 14). W&Wsens disclosed Vasylyev to the Office during examination of the '948 Patent, and the Office expressly allowed the claims of '948 Patent over Vasylyev. Ex. 1003 at 487 (IDS filed 9/3/2024); *id.* at 319 (IDS considered). In Grounds 2 and 4, Petitioners only rely on Vasylyev as allegedly disclosing limitations 13d(1) and 13d(2) wherein: “each of the holes (i) has an elongated shape extending in length over less than the width of the light-

receiving surface in which the hole is fabricated, (ii) has at least one closed contour at the light-receiving surface in which the hole is fabricated” (Claim 13). Pet. at 114-117; *see also id.* at 112-119 (arguing, by reference to Ground 1, that Kuboi allegedly discloses limitations 13(pre), 13a(1)-(2), 13b, 13c, 13d(2), 13e, 13f, 13g, 13h, 13i); D’Andrade Decl. at ¶ 99. Petitioners do not assert that Vasylyev discloses side-isolated pillars with in-pillar holes.

C. Shinohara Does Not Disclose Microstructures

Petitioners do not contend that Shinohara teaches any of the microstructure claim limitations of the Challenged Claims that are missing from Kuboi and Vasylyev. Shinohara describes an imaging device having a “backside illuminated structure” including “an element isolation region isolating the pixels.” Shinohara at Abstract. Petitioners cite Shinohara in Grounds 2 and 4 as allegedly disclosing, among other things, “a base dielectric region” (limitation [1f]) and monolithic integration (claim 2). Pet. at 128-132, 132-134 (Claims 3, 7-8, 9, 10, 11-12); D’Andrade Decl. at ¶¶ 100-101.

V. LEVEL OF ORDINARY SKILL IN THE ART

A person of ordinary skill in the art (“POSITA”) would have had at least a master’s degree in electrical engineering or a similar field and at least two years of experience working with semiconductor systems and semiconductor devices.

D'Andrade Decl. at ¶¶ 44-46. Additional relevant work experience can compensate for less education and vice versa. *Id.*

VI. CLAIM CONSTRUCTION

In its Petition, Petitioners assert that “no terms need construction.” Pet. at 6-7. Meanwhile in parallel district court litigation, the parties have taken specific claim construction positions. *See W&Wsens Devices Inc. v. Samsung Elecs. Co.*, Case No. 2:24-cv-00854-JRG (E.D. Tex.) (Ex. 2046). Both parties have submitted proposed claim constructions to the district court, and a claim construction order has not been issued yet. W&Wsens summarizes the parties’ competing proposed constructions for disputed claim terms in the tables below, as reflected in the district court record. The Challenged Claims are patentable under either parties’ proposed claim constructions.

Term	W&Wsens’ Proposed Construction	Petitioners’ Proposed Construction
“hole[s]”	Plain and ordinary meaning	Plain and ordinary meaning (e.g., not isolation trenches)
“holes that are fabricated as recesses at or under the light-receiving surface of each of at least some of the pillars . . .	Plain and ordinary meaning	“holes deliberately formed in a pillar of a photodetector for absorbing light that is converted to electricity”

Term	W&Wsens' Proposed Construction	Petitioners' Proposed Construction
extend[s] into the pillar[s]"		

Ex. 2046 (Ex. A at 1-2). The parties agreed in the parallel district court litigation that the following terms are not in dispute:

Term	Agreed Construction
"pillar"	Plain and ordinary meaning. No construction necessary.
"base dielectric region"	Plain and ordinary meaning. No construction necessary.

Ex. 2047 at 2.

VII. THE CHALLENGED CLAIMS ARE PATENTABLE OVER KUBOI, VASYLYEV, AND SHINOHARA (GROUNDS 1-4)

The Board should uphold the validity of the Challenged Claims because Kuboi, Vasylyev, and/or Shinohara do not teach or suggest at least the following limitations:

- (1) "an *array of pillars* comprising Si, Ge, and/or SiGe alloy semiconductor material,
- (2) "wherein at least some of the pillars are configured to include photodetectors and have respective light-receiving surfaces and respective sides; wherein at least some of the pillars comprise *P-doped and N-doped regions and are configured to respond to illumination*

with light in selected visible and infrared wavelengths by generating electrical charge carriers” (“Array of Pillars Limitation”);

(3) “one or more holes that are fabricated as recesses *at or under the light-receiving surface of each of at least some of the pillars*, ... and”

(4) “are *filled at least partly with solid dielectric material*,” or

(5) “wherein the presence of said one or more holes *increases by a factor of at least 1.1 the absorption of the light* by at least some of the photodetectors relative to like photodetectors lacking said holes” (“Increased Absorption Limitation”).

’948 Patent at 55:38-67 (Claim 1) (emphasis added). Each independent claim recites each of these limitations, and each limitation provides an independent basis to uphold the patentability of the ’948 Patent.

A. Kuboi Does Not Disclose an Array of Pillars (Grounds 1-4)

Kuboi does not disclose “an array of pillars comprising Si, Ge, and/or SiGe alloy semiconductor material, wherein at least some of the pillars are configured to include photodetectors and have respective light-receiving surfaces and respective sides.” D’Andrade Decl. at ¶¶ 104-106. As illustrated in Fig. 49 of the ’948 Patent, pillars are structural features with light receiving surfaces and sides:

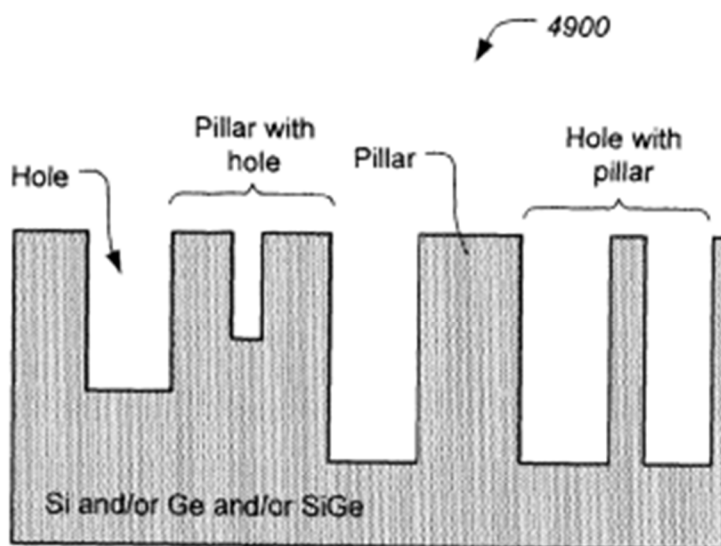
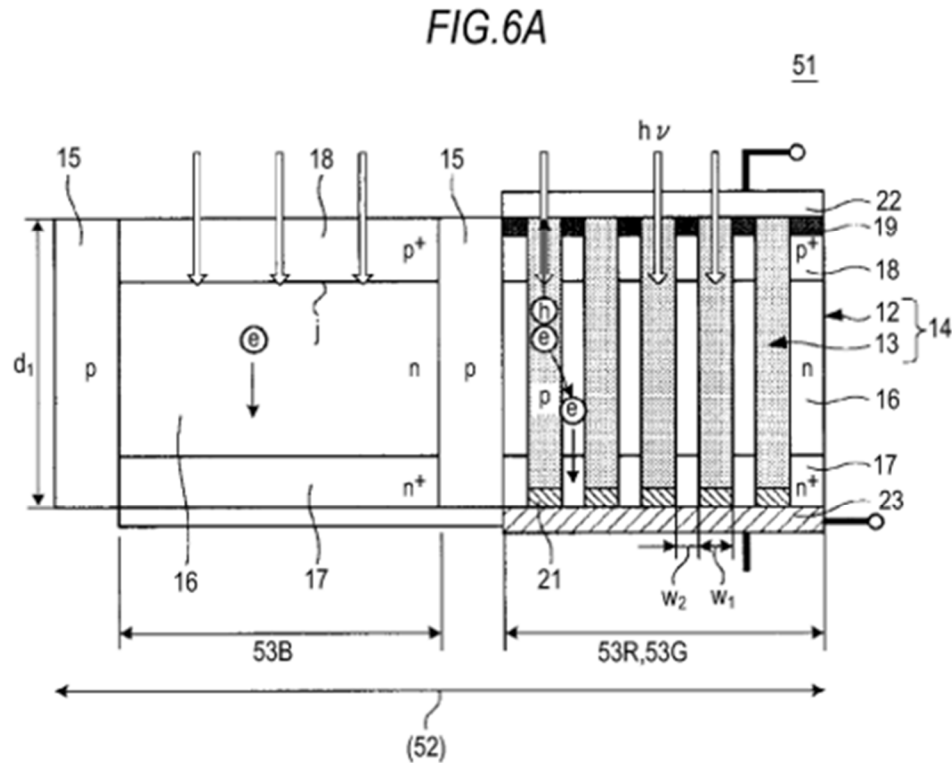


FIG. 49

'948 Patent, Fig. 49.

Kuboi's photodetectors are formed in a bulk silicon substrate that lacks any "pillars":



Kuboi, Fig. 6A. The image above shows two pixels, side-by-side. The pixel on the left in the figure above is designed to absorb blue light (shorter wavelength), which has a relatively high coefficient of absorption in Si. It includes no pillars or holes. The pixel on the right is designed to absorb green or red light (longer wavelengths), and it includes a series of holes filled with organic films 13 that absorb incident light, but there are no pillars as in the Challenged Claims, with respective light-receiving surfaces and "sides." D'Andrade Decl. at ¶ 105.

Accordingly, Kuboi does not disclose “an array of pillars comprising Si, Ge, and/or SiGe alloy semiconductor material, wherein at least some of the pillars are configured to include photodetectors and have respective light-receiving surfaces and respective sides,” as recited in the Challenged Claims. D’Andrade Decl. at ¶ 106.

B. Kuboi Does Not Disclose the Claimed Photodetectors (Grounds 1-4)

Kuboi also fails to disclose that the “array of pillars” is “configured to include photodetectors [that] comprise P-doped and N-doped regions and *are configured to respond to illumination with light in selected visible and infrared wavelengths by generating electrical charge carriers.*” ’948 Patent at 55:39-47 (emphasis added); Pet. at 14-26 (discussing limitations [1a(1)], [1a(2)], and [1b]); D’Andrade Decl. at ¶¶ 107-114.

The claimed photodetectors are formed in the Si/Ge/SiGe pillars and must include photosensitive “P-doped and N-doped regions” that absorb light and generate “electrical charge carriers.” In accordance with the claims, the specification describes silicon and germanium light absorption regions that generate electrical charge carriers. ’948 Patent at 3:6-35 (describing “the absorbing region and the microstructures are formed of silicon”); *id.* at 3:36-61 (describing “the absorbing semiconductor region and the microstructures are formed of silicon and

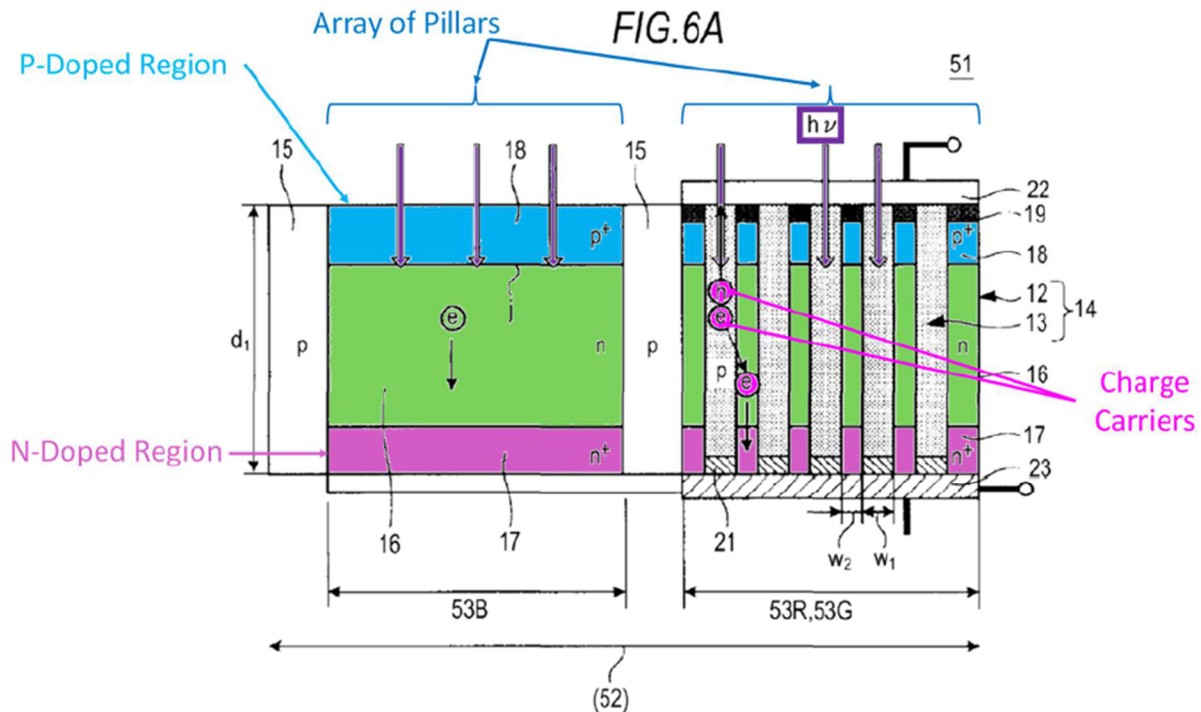
germanium”); *id.* at Fig. 5B, 16:9-29 (describing Fig. 5B and the photodetector “photosensitive area (defined by the --PIN . . . junction area)”).

Kuboi's semiconductor layer 12 does not “respond to illumination with light in selected visible and infrared wavelengths by generating electrical charge carriers,” as claimed. Pet. at 22-26. A “light shielding film 19” ensures “that light $h\nu$ does not enter the semiconductor layer 12.” Kuboi at [0059], [0064] (“The light $h\nu$ does not enter the semiconductor layer 12 due to the light shielding film 19.”). During cross-examination, Petitioners' expert Dr. Lebby admitted that “Kuboi has the intention of light-shielding film 19 to prevent direct incident light from entering P region 18 of the semiconductor.” Ex. 2048 (“Lebby Tr.”) at 102:17-21, 103:2-5; D'Andrade Decl. at ¶¶ 109-110.

Rather than use microstructures to enhance photon absorption in the Si/Ge/SiGe-based semiconductor layers of the photodetector, Kuboi proposes a “hybrid” photodetector, where electron-hole pairs are generated in organic material layers *instead of* in P-doped or N-doped Si/Ge/SiGe semiconductor layers, as claimed. Kuboi at [0057] (organic material layers 13 are “where photoelectric conversion is performed”); *id.* at [0011]-[0012] (“hybrid photoelectric conversion portion in which photoelectric conversion is performed in the organic material layer”); *id.* at [0014] (“Photoelectric conversion is performed in the organic material

layer of the hybrid photoelectric conversion portion, . . .”); *see also id.* at [0076], [0080], [0082], [0107].

Kuboi discloses generating charge carriers in the organic material layer 13, not in a P-doped or N-doped semiconductor layer, like semiconductor layer 12:



Pet. at 25 (citing Kuboi, Fig. 6A (annotated)); Kuboi at [0002]-[0004] (describing that Kuboi's device absorbs light “in . . . an organic material layer . . . used as the photoelectric conversion portion”); '948 Patent at 55:44-47 (Claim 1).

Kuboi's imaging device does not, therefore, include silicon/germanium pillars comprised of “P-doped and N-doped regions” that are “configured to respond to illumination with light in selected visible and infrared wavelengths by generating electrical charge carriers.” Pet. at 22-26. Instead, Kuboi's “photoelectric conversion

films 13” (which Petitioners allege are microstructure holes) are the elements that absorb incoming light and generate charge carriers. D’Andrade Decl. at ¶¶ 112.

With respect to the *ex parte* re-examination request of the related ’871 Patent, the Office likewise found that Kuboi does not teach an array of pillars:

Kuboi teaches, among other things, elements 38 as shown in Figure 4B that are “holes” at least in the sense that they are negative spaces formed in the semiconductor layer 12. However, ***Kuboi does not teach pillars that are configured as photodetectors that have respective light-receiving surfaces and are configured to respond to illumination with light in selected visible and infrared wavelength ranges by generating electrical charge carriers***; and one or more holes that are deliberately formed into the light-receiving surfaces and are filled at least partly with solid dielectric material as recited in claim 1. Even if for the sake of argument Kuboi teaches “pillars” comprising the remaining sections of semiconductor layer 12 that are not removed in holes 38, holes 38 are not deliberately formed into the light-receiving surfaces of the pillars and holes 38 have organic photoelectric conversion film 13 therein (not solid dielectric; Figures 1A and 6A; paragraphs [0064] and [0091]-[0093]). ***The remaining sections of semiconductor layer 12 are not pillars that have respective light-receiving surfaces*** and are configured to respond to illumination with light in selected visible and infrared wavelength ranges by generating electrical charge carriers as recited in claim 1, because Kuboi teaches that the remaining sections of semiconductor layer 12 are covered by light shielding film 19 such that light photons would be incident on the organic photoelectric conversion

film 13 in holes 38, not the semiconductor layer 12 (Figures 1A and 4F; paragraphs [0064] and [0076]).

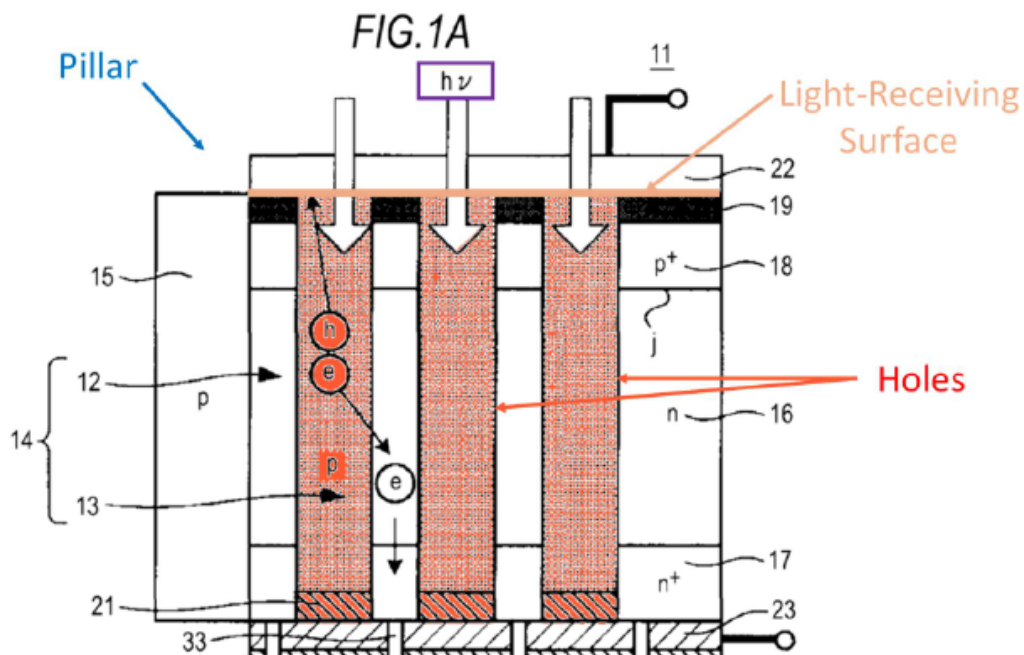
Ex. 2040 ('871 EPR) at 7 (emphasis added). Petitioners fail to show why the Office, faced with the same prior art references and arguments, should reach a different result here.

For these reasons, Kuboi fails to disclose an “array of pillars” that is “configured to include photodetectors [that] comprise P-doped and N-doped regions and are configured to respond to illumination with light in selected visible and infrared wavelengths by generating electrical charge carriers,” as required by the Challenged Claims. D’Andrade Decl. at ¶ 114.

C. Kuboi Does Not Disclose Holes Fabricated as Recesses At or Under the Light-Receiving Surface of Each Pillar (Grounds 1-4)

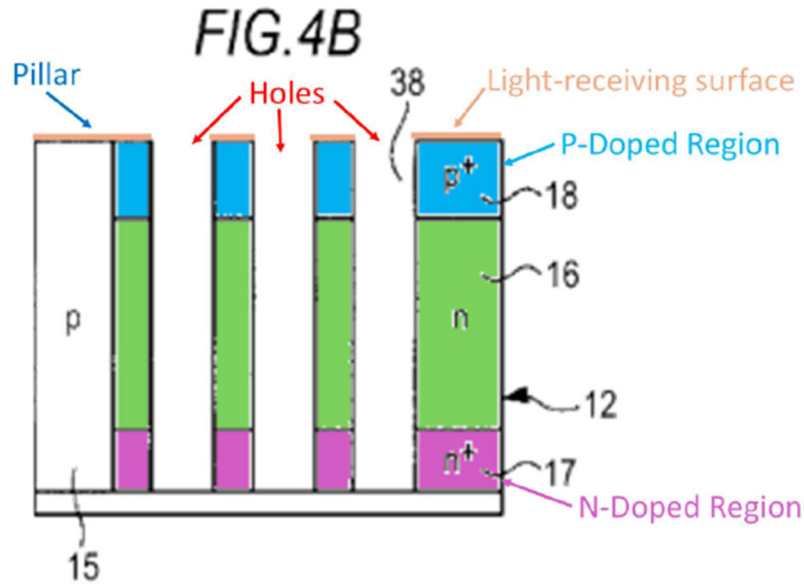
Kuboi fails to teach or suggest “one or more holes that are fabricated as recesses at or under the light-receiving surface of each of at least some of the pillars,” as recited by the Challenged Claims. D’Andrade Decl. at ¶¶ 115-120.

Petitioners map the claimed pillar’s “light-receiving surface” to “the light incident side . . . of Kuboi’s pixels” that is “located on upper electrode 22’s lower surface.” Pet. at 18 (discussing limitation [1a(2)] that provides antecedent basis for “light-receiving surface”); *id.* at 26-30 (discussing limitation [1c]); *see also* Lebby Tr. at 84:13-85:10 (confirming this position).

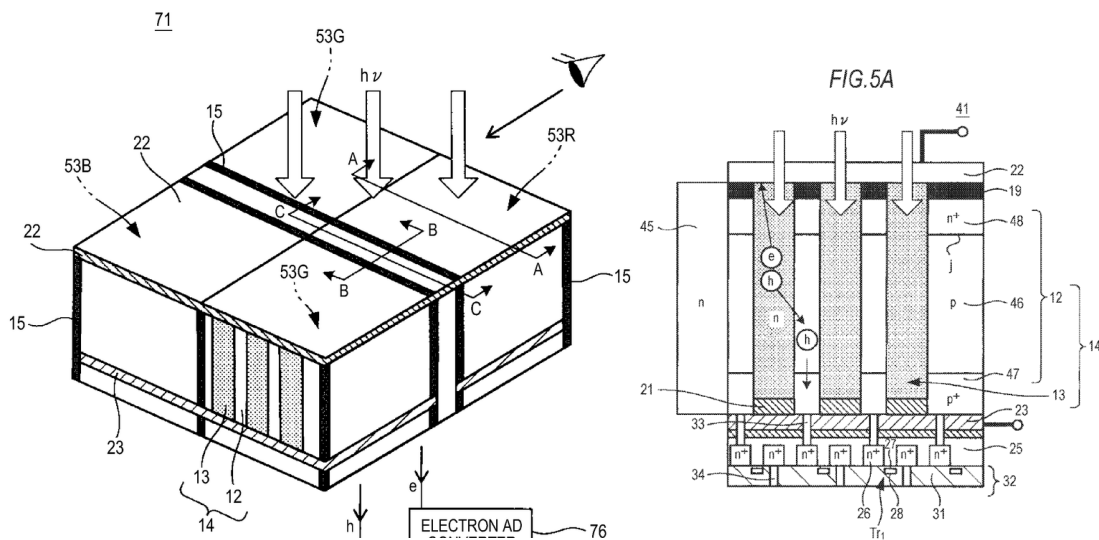


Pet. at 28 (citing Kuboi, Fig. 1A, annotated) (excerpted). This mapping fails for two reasons:

First, Kuboi’s holes are not fabricated at or under the lower surface of the upper electrode 22. Kuboi’s alleged holes are, in fact, fabricated into the top of the p-type region 18, which is not a light-receiving surface:



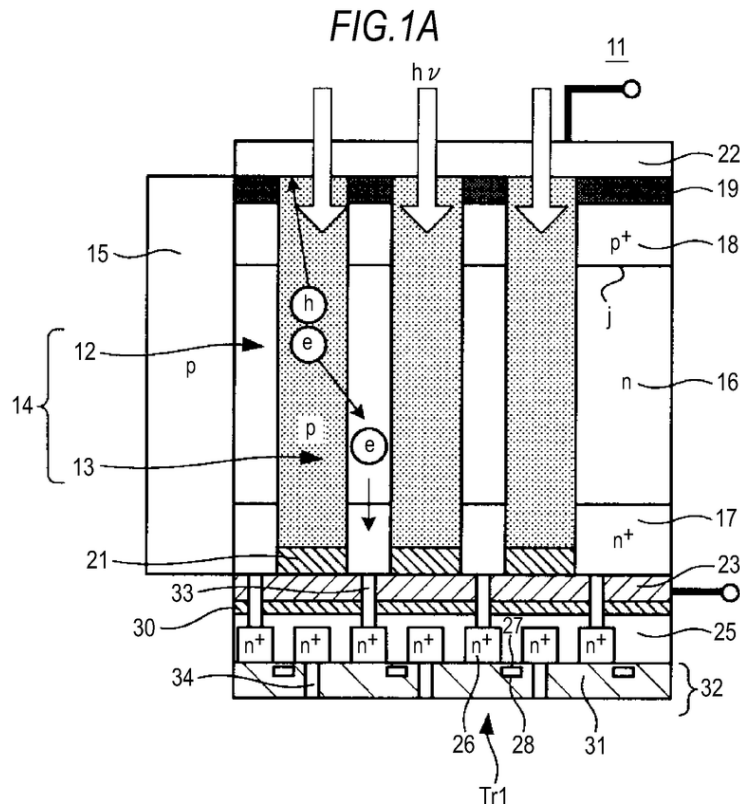
Pet. at 27 (citing Kuboi, Fig. 4B (annotated)); see Kuboi at [0072] (disclosing openings dry-etched into region 18). As illustrated below, there are no holes fabricated as recesses at any surface of the upper electrode 22:



Kuboi, Figs. 13 (excerpted) and 5A (showing a solid electrode with no holes fabricated as recesses in the top surface, middle, or bottom surface of upper electrode 22). Petitioners' expert Dr. Lebby confirmed during his deposition that the upper

electrode 22 “does not have holes etched in it.” Lebbby Tr. at 104:21-105:8; D’Andrade Decl. at ¶¶ 117-118.

Second, the top of p-type region 18 (where the holes are actually etched) is not a light-receiving surface. Light-shielding film 19 covers the upper surface of the p-type region 18 precisely to prevent incident light from reaching the semiconductor layer 12. Kuboi at [0064] (“The light $h\nu$ does not enter the semiconductor layer 12 due to the light shielding film 19.”).



Id., Fig. 1A (showing light $h\nu$ entering holes and not the semiconductor layer 12 due to the light shielding film 19). Because light shielding film 19 blocks incident light from reaching p-type region 18, the top surface of p-type region 18 cannot serve as

a “light-receiving surface” within the meaning of the Challenged Claims. Kuboi’s holes are etched into regions that are shielded from incident light, not at or under the alleged light-receiving surface. D’Andrade Decl. at ¶ 119.

Accordingly, Kuboi does not disclose “one or more holes that are fabricated as recesses at or under the light-receiving surface of each of at least some of the pillars,” as required by the Challenged Claims. D’Andrade Decl. at ¶ 120.

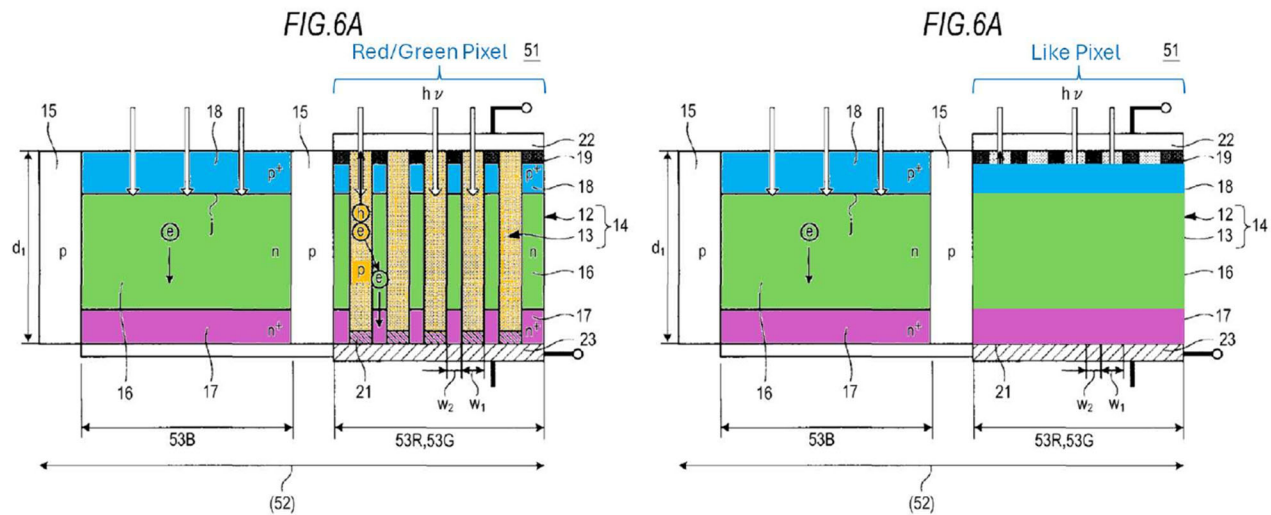
D. Kuboi Does Not Disclose the Increased Absorption Limitation (Grounds 1-4)

Kuboi fails to disclose “holes” wherein “the presence of the one or more holes increases, by a factor of at least 1.1, absorption of the light by at least some of the photodetectors relative to like photodetectors lacking said holes.” ’948 Patent at 55:64-67 (limitation [1h]), 57:5-8 (limitation [13h]) (similar); Pet. at 40-52. None of the asserted references disclose the “hole” microstructures or an improvement to the light absorption properties of photodetectors because of the “hole” microstructures. D’Andrade Decl. at ¶¶ 121-132.

Petitioners do not argue that Kuboi discloses that the presence of alleged in-pillar holes increases light absorption by at least 1.1 times, as the Challenged Claims require. Pet. at 40-52, 118. Instead, Petitioners try to substitute for the absence of this disclosure in the reference by relying on 24 pages of expert testimony purporting to estimate an improvement in light absorption from the references’ proposed

designs. *Id.* at 40-52 (citing Lebbly Decl., ¶¶ 175-201). Dr. Lebbly's opinions are unreliable and at odds with the record evidence.

Dr. Lebby attempts to calculate a hypothetical amount of light absorption for Kuboi's pixels based on the Lambert-Beer Law and a series of assumptions stemming from its pixel dimensions. Ex. 1002 ("Lebby Decl."), ¶¶ 175-187. To do so, Dr. Lebby purports to compare the photodetectors to alleged "like photodetectors lacking said holes:"³



³ On cross-examination, Dr. Lebby clarified that only the “like pixel without in-pillar holes” mapped to the claimed “like photodetectors lacking said holes.” Lebby Tr. at 146:2-9. As such, Dr. Lebby’s alternative analysis regarding “Hypothetical pixel without in-pillar holes and no light shield” is not relevant to the Challenged Claims’ validity and should be disregarded. Lebby Decl., ¶¶ 181, 183-187.

Id., ¶ 180 (citing Kuboi, Fig. 6A (annotated) (left image depicting “53R/53G pixel with organic material in the in-pillar holes”; right image depicting “like pixel without holes”).

However, the alleged holes of Kuboi contain the active photo sensing materials (organic materials), and it would be illogical to a POSITA to produce a “like photodetector” that lacks holes and expect the imaging device to perform any photon sensing at all. D’Andrade Decl. at ¶¶ 124-126.

A POSITA would also understand that any purported improvement in light absorption by Kuboi is attributed to the selection of the organic photosensitive material (over silicon), rather than the presence of any structural elements, like the holes recited in claim limitations [1d]. Dr. Lebby admitted this at cross-examination:

Q: So is it fair to say in your analysis on paragraphs 180 to 181, that the purported increase of light absorption is due to the use of organic photoelectric conversion films?

A: ***That is the essence of what Kuboi is teaching.*** Kuboi is teaching that if you use an organic film that has the characteristics of high absorption, and I demonstrated one of those chemistry names, there’s high absorption in the red, and the other one has a high absorption in the green, you can do that -- the benefit of improving the performance of the photodetector by increasing the absorption by 1.1 X or more. If you don’t use the high absorption material and compare it to a like pixel, which as I did as you can see on the right-hand side of the figures in page 100 of my declaration, you can see through the simple analysis

I did as an engineer and person of ordinary skill in the art that you can still invalidate the claim element, but the absorption is less.

Lebby Tr. at 147:7-148:5 (emphasis added).

Second, Dr. Lebby's opinion is based on improper hindsight because it uses the Challenged Claims and specification of the '948 Patent as a roadmap to try to recreate the claimed invention from asserted prior art. For example, Dr. Lebby argues "Patent Owner represents in the '948 Patent that an imaging device having the structure disclosed in *Kuboi* would improve photon absorption by at least 10%." Lebby Decl., ¶ 188. This argument is conclusory and rooted in hindsight. D'Andrade Decl. at ¶¶ 128-129. During cross-examination, Dr. Lebby admitted to using the '948 Patent as a roadmap, stating he "wanted to see what is expressly taught in the '948 that would cause the enhancement of absorption and apply what is being taught in *Kuboi* into the equation given in the '948 to see if it really does increase absorption by 1.1 X." Lebby Tr. at 152:8-18.

Third, Petitioners cite an external reference, Han (Ex. 1038), for its discussion of the alleged "impact of nanoholes on the ultimate efficiency associated with photon absorption." Pet. at 50-51 (citing Ex. 1038, Fig. 4). Han's Fig. 4 is "a graphical plot of the calculated ultimate efficiency as a function of the thickness of the nanohole array, the nanorod array, and the homogeneous c-Si film (a) with and (b) without a Si₃N₄ antireflection (AR) coating." Ex. 1038 at 5:31-33. But Han's graphs do not

concern or disclose the efficiency of in-pillar holes because Han does not disclose or suggest the use of in-pillar holes. D'Andrade Decl. at ¶¶ 130-131.

Petitioners offer no explanation for how Han's discussion of the efficiency of its "nanoholes" applies to the efficiency of Kuboi's very different hybrid photoelectric conversion portion and organic photoelectric conversion film. Pet. at 50-51. There, Han adds nothing of probative value to Petitioners' theory and cannot substitute for an actual disclosure in Kuboi of in-pillar microstructures that enhance absorption in by at least a factor of 1.1. D'Andrade Decl. at ¶ 131.

Therefore, Petitioners fail to show that any of their asserted grounds disclose or achieve the claimed improvement in light absorption. D'Andrade Decl. at ¶ 132.

E. Kuboi Does Not Disclose Holes That are Filled at Least Partly with Solid Dielectric Material (Grounds 1-4)

Kuboi fails to disclose "one or more holes . . . [that] are filled at least partly with solid dielectric material" because Kuboi's holes 38 are not filled with solid dielectric material. There are multiple reasons that Petitioners are incorrect to contend that "electron blocking film 21 and photoelectric conversion film 13 together entirely fill Kuboi's holes and are solid dielectric materials." Pet. at 31; D'Andrade Decl. at ¶¶ 133-150.



Pet. at 31 (citing Kuboi, Fig. 1A (annotated)).

First, as a matter of claim construction, the requirement that the holes be “filled at least partly with solid dielectric material” (’948 Patent at Claim 1) means that the solid dielectric material must at least partly fill the volume of the hole—not merely coat a surface at the bottom. This construction is supported by the specification, which discloses filling or partly filling holes with a solid dielectric material, “such as silicon nitride, or silicon oxide.” ’948 Patent at 19:30-42 (disclosing a filler 916 that fills or partially fills the space between the Si pillars 914, rather than only a thin liner on the bottom of the space).

Under this construction, Kuboi's thin SiO₂ liner followed by an organic material bulk fill does not satisfy the limitation. D'Andrade Decl. at ¶ 134. In contrast to Kuboi's approach, the '948 Patent teaches that a partial fill of the hole

may result in the rest of the hole being filled with air, which has significant benefits to device performance:

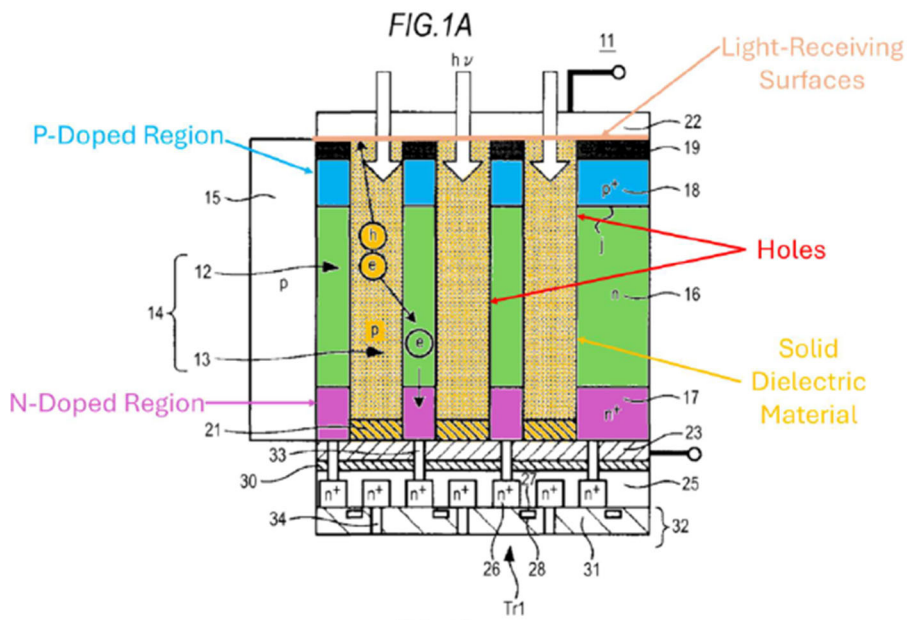
In FIG. 9D a filler 916 is used to ***fill or partially fill the space*** between the Si pillars 914 to support subsequent contact layers to be deposited. The filler 916 can be spin on glass, polyimide, dielectric such as silicon nitride, or silicon oxide, that can be deposited for example using plasma enhanced chemical vapor deposition. Once the contacts are made the fillers can be left in place or removed by dissolving the filler with an etchant or solvent. ***Removing the filler has an advantage of further reducing the capacitance of the device since air has a dielectric constant of 1.*** The reduction of the capacitance allows the device to operate at higher bandwidth due to reduction of the RC time.

'948 Patent at 19:30-42 (emphasis added); *see also id.* at 21:18-38 (disclosing that similar fabrication processes are used to create “microstructured hole arrays” as the “light traps,” and that “[i]n the case of the hole arrays, it is possible that the filler need not extend the entire length of the hole”).

The '948 Patent explains that it is beneficial to fill microstructure holes with a low-capacitance, low-refractive index material to enhance device bandwidth (by reducing capacitance) and increasing light absorption (via high contrast grating effects). *See, e.g.,* '948 Patent at 9:4-14, 9:56-10:5; D'Andrade Decl. at ¶ 135. Accordingly, partly filling the holes with a solid dielectric material, and leaving the rest filled only with air or vacuum, improves device performance because

air/vacuum has even more desirable properties than solid dielectrics. '948 Patent at 19:38-40. Accordingly, while some amount of dielectric filler material is necessary during fabrication, the '948 Patent teaches that at least some of that filler material may be stripped away, leaving air in its place, which has the desirable benefit of reducing capacitance and increasing absorption. *Id.* at 19:30-42.

Kuboi's holes 38 are not "filled at least partly" with electron blocking film 21. An electron blocking film coats only the bottom of the holes, which are *fully* filled with an organic material:



Pet. at 31 (citing Kuboi at Fig. 1A (annotated)); *see* Kuboi at [0073] (disclosing that electron blocking film 21 is a thin film that is only "several tens of nm [nanometers]" in thickness). Accordingly, holes 38 are not "filled at least partly with solid dielectric material," they are fully filled with *semiconducting* material. Kuboi at

[0073]. Kuboi's organic semiconductor is designed to be optically and electrically active to absorb photons and transport charge carriers, not to function as a passive, low-k, solid dielectric or to create a beneficial air void. *Id.* at [0057]; D'Andrade Decl. at ¶¶ 137-138. Thus, Kuboi teaches away from at least partly filling holes with solid dielectric material.

Second, because Kuboi's electron blocking film 21 does not at least partly fill holes 38 Petitioners take the untenable position that Kuboi's photoactive organic materials ("perylene-based compounds, phthalocyanine compounds, quinacridone compounds, porphyrin compounds, merocyanine compounds") are solid dielectric materials. Pet. at 30-31 (quoting Kuboi at [0058]). They are not. D'Andrade Decl. at ¶¶ 139-150.

The term "dielectric material" is well-understood in the art to mean an **insulator** that can be polarized in an electric field and is different from a semiconductor:

dielectric (1) a medium that exhibits negligible or no electrical conductivity and thus acts as a good electrical insulator. (2) a medium characterized by zero conductivity, unity relative permeability, and a relative permittivity greater than one. Also known as an insulator.

Ex. 2029 at 3 (Electrical Engineering Dictionary); *see also id.* at 4 ("**dielectric medium** – medium that is polarizable but relatively nonconducting"); D'Andrade Decl. at ¶ 140.

Samsung's own extrinsic evidence confirms that semiconductors are different from dielectric layers. *See* Ex. 1012 at 20 (“Dielectric layers such as silicon dioxide and silicon nitride are used for insulation between conducting layers”). Dielectric materials, like all insulators, are not suitable for photoconversion because they lack the necessary band structure to create signal charges when illuminated. Ex. 1028 at 22-25 (discussing optical absorption and photogeneration in *semiconductor materials*).

Kuboi also cites to references that establish that organic photoconversion films are not dielectric materials. *See, e.g.*, Kuboi at [0005] (citing Ex. 2030 (JP Patent 3423279), “Hiramoto”); D’Andrade Decl. at ¶¶ 141-142. According to Kuboi, Hiramoto discloses a “method of effectively extracting electrons generated by photoelectric conversion using an organic film made of two kinds of organic materials.” Kuboi at [0005]. Accordingly, Kuboi states that its organic layers may include “*perylene*-based compounds, *phthalocyanine* compounds,” (*id.* at [0058] (emphasis added)), and Hiramoto discloses that those layers are semiconducting materials, not dielectrics. Ex. 2030 (Hiramoto) at 6 (“A preferable example of the *organic semiconductor layer* is a co-evaporated thin film of a *phthalocyanine* pigment and a *perylene* pigment.”); *see also id.* at 5 (“[A]n organic *semiconductor* thin-film solar cell having a structure in which co-deposited thin films of two kinds of organic semiconductors are sandwiched between electrodes.”) (emphases added);

Ex. 2033. Therefore, Kuboi's organic films are not dielectrics. Kuboi's organic material is designed not to be an insulator because one of its essential functions is to transport sideways, to the surrounding Si, the electrical charges that that organic material generates in response to impinging light.

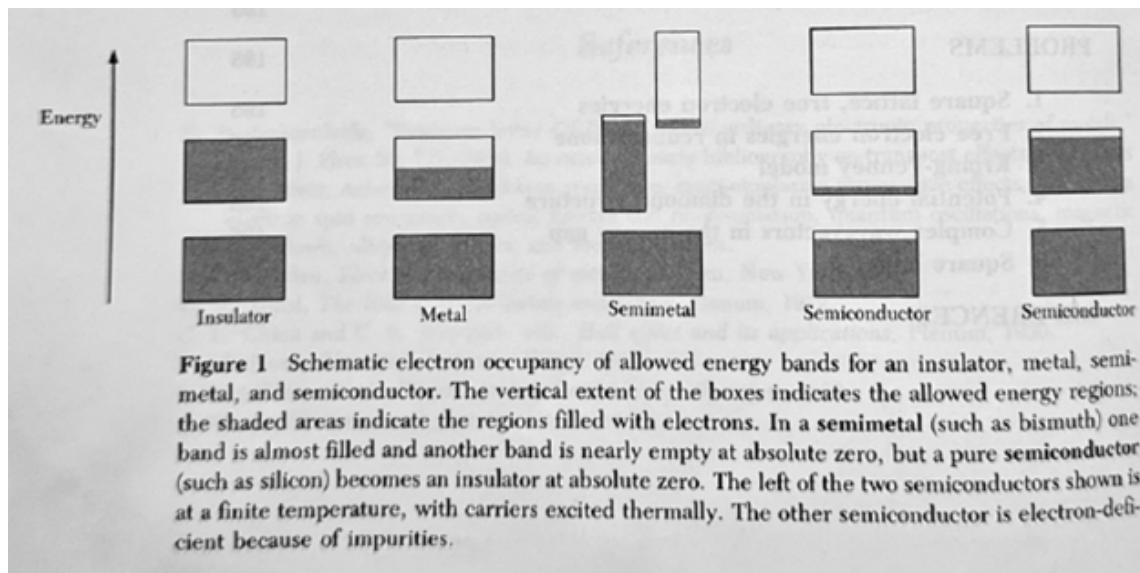
In view of the foregoing, the Board should reject Dr. Lebby's claim that a "POSITA would have understood that phthalocyanine, perylene-based, and porphyrin compounds are solid dielectric materials" because it is plainly erroneous and contradicted by the cited reference itself. Pet. at 30-31 (citing Lebby Decl., ¶¶ 150-152); D'Andrade Decl. at ¶ 143. Further, Dr. Lebby's opinion in his declaration is based on the incorrect notion that any material with a "dielectric constant" or "dielectric properties" is a dielectric material. Lebby Decl., ¶ 151. The term "dielectric constant" merely refers to "an electric property of an insulator or semi-conducting material, which describes how differently electric fields will behave inside of the material as compared to air." Ex. 2029 at 3-4 (Electrical Engineering Dictionary) (definition of "dielectric constant"). Indeed, Dr. Lebby opines elsewhere that "silicon nitride (Si_3N_4) and silicon oxide (SiO_2) are solid dielectric materials" *because* they are insulators. Lebby Decl., ¶ 146.

Accordingly, although semiconductors can have non-zero dielectric constants and measurable "dielectric properties," they are not dielectric materials because they are not insulators:

The crystal behaves as an insulator if the allowed energy bands are either filled or empty, for then no electrons can move in an electric field. The crystal behaves as a metal if one or more bands are partly filled, say between 10 and 90 percent filled. The crystal is a semiconductor or semimetal if one or two bands are slightly filled or slightly empty.

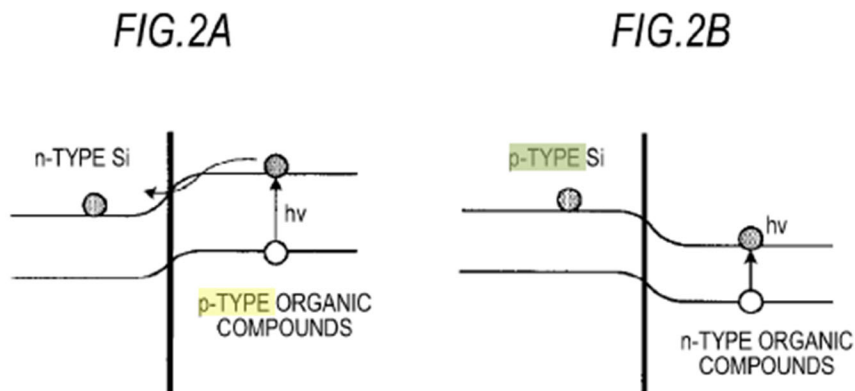
Ex. 2025 (Kittel) at 7.

Energy bands for different types of materials are illustrated below:



Id. at 6; *see also* D'Andrade Decl. at ¶ 144.

Kuboi's organic films are semiconducting because they are characterized as p-type or n-type materials that carry signal charges. *See, e.g.,* Kuboi at [0055], [0056], [0085]; D'Andrade Decl. at ¶ 145. By definition, organic semiconductors that are doped to be p-type or n-type and that carry signal charges are not dielectric materials because they are not insulators. Ex. 2029 at 3 (Electrical Engineering Dictionary) (definition of "dielectric").



Kuboi, Figs. 2A and 2B (illustrating electron excitation in the band diagram of semiconducting organic compounds, which could not occur in an insulator due to its band structure); *see also, e.g., id.* at [0057] (“In this example, since signal charges are electrons, the organic photoelectric conversion film 13 is formed of a p-type organic material.”); [0058] (“As the p-type organic material, organic compounds which have a desired absorption band and satisfy an energy band structure shown in FIG. 2A described later are used.”); [0085] (“The organic photoelectric conversion film 13 is formed by an n-type organic material. As the n-type organic material, organic materials such as, for example, naphthalene-based compounds, perylene-based compounds, and C60 can be used.”).

Petitioners’ own exhibits acknowledge that “[d]ielectrics are basically insulator materials Some semiconductors have also similar properties,” meaning the primary definition of a dielectric is an insulating material, and that even though some semiconductors merely exhibit similar properties, they are not reclassified as dielectrics. Ex. 1015 at 1; D’Andrade Decl. at ¶¶ 146-147. Dr. Lebby conceded that

a POSITA “wouldn’t characterize a semiconductor material as a dielectric material.” Lebby Tr. at 127:3-9; *see also id.* at 126:15-17 (“to me, a semiconductor is a semiconductor, and a dielectric material is a dielectric material”). A POSITA would understand that a semiconductor being studied for its polarization response does not thereby become a dielectric material.

Dr. Lebby’s cross-examination testimony on this issue amounted to an admission that he was relying on the organic film’s semiconducting behavior rather than a definition of dielectric material. Dr. Lebby opined that polymers are dielectric material because they can at times, “depending on the condition,” be insulating. Lebby Tr. at 123:20-124:5. When asked whether a photoconductive polymer that generates charge carriers under illumination would be typically considered an electrical insulator in the photodetector field, Dr. Lebby opined that “it depends on the condition of the material, whether the material is in a situation where it’s in a insulated mode or it’s in a conductive mode, for example.” *Id.* at 140:17-20, 141:2-5.

But this variable behavior is akin to semiconductor material, which a POSITA understands is not a dielectric material. D’Andrade Decl. at ¶¶ 147-148. During cross-examination, Dr. Lebby describes the trademark characteristics of semiconductors, which he acknowledges are not dielectric materials while simultaneously arguing that Kuboi’s organic materials are dielectrics:

Semiconductors with materials such as silicon can be made semiconducting, that *can be made highly conducting, that can be made less conducting*, but the advantage of using organic materials is that, you know, the dielectric organic materials can be conducting in one situation, for example, in a dark environment, and you can excite those materials with light and . . . *you can make them conducting with light, and you can make them insulating in a dark environment.*

Lebby Tr. at 32:12-22 (emphasis added); *see also id.* at 31:1-7 (“In a dielectric material, for example, one of the advantages of using organic polymer materials such as the ones that Kuboi expressly indicates is that these materials are dielectric materials, but *depending on the situation, you can make them conducting or you can make them insulating . . .*”) (emphasis added). A POSITA would understand that Kuboi’s organic material that generates signal charges in response to light and transports those charges laterally to a surrounding silicon layer is functioning as a semiconductor in the device, not as a passive insulating dielectric fill. D’Andrade Decl. at ¶¶ 148-150.

For these reasons, Kuboi fails to disclose the claimed “one or more holes . . . are filled at least partly with solid dielectric material.”

F. Vasylyev and/or Shinohara Fail to Supply Kuboi’s Missing Elements (Grounds 2-4)

Vasylyev and Shinohara do not disclose any of the claim limitations shown above to be missing from Kuboi. *See* §§ IV.B-C, VII.A-E. Nor do Petitioners rely

on or allege Vasylyev or Shinohara as providing these limitations. Pet. at 69-77 (relying on Vasylyev only for single-port and elongated-hole teachings); *id.* at 123-128 (relying on Shinohara only for monolithic integration and base dielectric region). Accordingly, for at least the reasons above, even if a POSITA were properly motivated to combine these references, Vasylyev and Shinohara fail to cure the deficiencies of Kuboi and the combination would not yield the claimed invention. D'Andrade Decl. at ¶ 152.

VIII. THE '948 PATENT IS ENABLED BY ITS SPECIFICATION (GROUND 5)

The Challenged Claims are enabled because, as Petitioners admit, the specification teaches a POSITA how to make and use the claimed invention. Pet. at 46-47 (relying on explanations found in '948 Patent specification); *see id.* at 4-6. Petitioners' inconsistent allegations that the Challenged Claims lack enablement find no basis in the law and fundamentally misread the claim language.

A. The Specification Teaches a POSITA How to Make and Use the Claimed Invention

To establish a lack of enablement, Petitioners must show “that a person of ordinary skill in the art would not be able to practice the claimed invention without undue experimentation.” *Enzo Life Sciences, Inc. v. Roche Molecular Sys., Inc.*, 928 F.3d 1340, 1345 (Fed. Cir. 2019) (internal quotation marks omitted). “Whether undue experimentation is needed is not a single, simple factual determination, but

rather is a conclusion reached by weighing many factual considerations.” *In re Wands*, 858 F.2d 731, 737 (Fed. Cir. 1988). These factors, referred to as the *Wands* factors, include: (1) the quantity of experimentation necessary, (2) the amount of direction or guidance presented, (3) the presence or absence of working examples, (4) the nature of the invention, (5) the state of the prior art, (6) the relative skill of those in the art, (7) the predictability or unpredictability of the art, and (8) the breadth of the claims. *Id.* Here, Petitioners do not allege any such deficiency in the '948 Patent's specification. Nor do Petitioners even attempt to engage in any inquiry under the *Wands* factors. Pet. at 139-140.

First, Petitioners' conditional argument that the claims are not enabled if “the prior art's disclosure is deemed insufficient” is meritless. Pet. at 139-140. As established above, Kuboi has an entirely different design for light detection than the '948 Patent. Kuboi does not purport to rely on the high contrast grating (HCG) effect, so Petitioners are wrong to assume that a deficiency in Kuboi “necessarily” establishes an enablement issue. D'Andrade Decl. at ¶ 155.

Petitioners' conditional argument also conflates the sufficiency of prior art disclosure in satisfying Challenged Claims with the enablement of the Challenged Claims. Pet. at 139-140. These are two distinct legal inquiries. Prior art sufficiency for anticipation or obviousness asks whether the **prior art discloses** a limitation to a POSITA. In contrast, enablement under § 112(a) asks whether the patent's **own**

specification enables a POSITA to make and use the full scope of the claimed invention without undue experimentation. The fact that Kuboi may or may not satisfy the 1.1x light absorption limitation says nothing, by itself, about whether a POSITA could achieve that threshold using the '948 Patent's specification. The two inquiries address different documents and different technical questions.

Second, the '948 Patent enables embodiments of “one or more” holes of claims 1 and 13 or “only one of the elongated holes” of claims 4 and 14 with respect to the claimed 1.1 factor requirement. Pet. at 140-141; D'Andrade Decl. at ¶ 157. Petitioners do not dispute that the '948 Patent enables embodiments having a single in-pillar hole. Pet. at 140. Petitioners also do not dispute that the '948 Patent enables embodiments that increase the absorption of light by a factor of at least 1.1 compared to like photodetectors without such in-pillar holes. *Id.*

Petitioners incorrectly assume that the “high contrast grating (HCG)” effect is the sole physical mechanism underpinning the '948 Patent claims. Pet. at 140-141 (citing HCG as “the described mechanism for determining increased absorption”); D'Andrade Decl. at ¶ 158. The '948 Patent specification discloses that in “some embodiments”, the properties of the claimed microstructures “can also be explained” (i.e., indicating there are multiple explanations) by the “absorption mode of high contrast grating (HCG).” '948 Patent at 9:4-8. The '948 Patent explains that multiple physical mechanisms contribute to the increased efficiencies introduced by

the claimed microstructures. *Id.* at 8:37-65 (describing “resonance/scattering/near field effects of microstructures” on “path length”), 11:52-57 (“The cause or causes of the enhancement of the absorption coefficient are believed to include one or more of the following: an increase in optical field concentration, resonance effects, constructive and destructive optical interferences (amplitude and phase) effects, scattering, and high contrast grating (HCG) effects.”); *id.* at 8:9-9:14 (generally).

Petitioners’ position that “a POSITA would have anticipated a substantial change in the HCG effect at lower values of the period Λ ” is unsupported and conclusory. Pet. at 141; D’Andrade Decl. at ¶ 159. Petitioners cite to their expert declaration, but Petitioners’ expert only parrots the same conclusory sentence and then cites the entirety of an academic paper titled “Size effect of high contrast gratings in VCSELs,” with no additional commentary or explanation of this paper’s relevance to its enablement argument. Lebby Decl. ¶ 362 (citing Ex. 1051, 1-6). Without more explanation, the academic paper’s subject matter (“vertical cavity surface-emitting laser (VCSEL)”) and discussion fail to raise doubts that a POSITA would have been able to practice the full scope of the Challenged Claims. Ex. 1051, Abstract. Thus, Petitioners fail to establish that a POSITA would require undue experimentation to practice these claims.

B. The Examiner in a Divisional Application's Examination Dropped a § 112(a) Rejection in Response to Patent Owner's Arguments

There is no merit to Petitioners' allegation of lack of enablement based on the Examiner's rejection of Application No. 19/036,506 ("the '948 Divisional") for lack of enablement. Pet. at 141-142. The Examiner dropped this rejection in response to W&Wsens' explanations and arguments during prosecution. Ex. 1050 ('948 Divisional File History from Jan. 24, 2025, to Jun. 13, 2025) at 7-8 (rejecting then-pending claims 1-12 for lack of enablement under § 112(a)); D'Andrade Decl. at ¶¶ 160-162. Thus, the '948 Divisional file history confirms enablement.

W&Wsens demonstrated to the Office the full enablement of the '948 Divisional's claim limitations that were at issue (and that are relevant to this case). Ex. 2034 ('948 Divisional File History from Sept. 16, 2025, to Nov. 21, 2025) at 145-147 (September 26, 2025, Supplemental Response to Office Action). For example, the '948 Patent discloses that "the height of a pillar can be 100-10000 nm." *Id.* at 146 (citing Ex. 2035 (U.S. Provisional Application No. 61/826,446 filed May 22, 2013, page 12) ("[P]illars can be 100-10000 nm in length")). The '948 Patent also discloses that "[t]he presence of the in-pillar holes increases absorption by a factor of at least 1.1. compared to like photodetectors without holes or to bulk semiconductor without holes." Ex. 2034 at 147 (citing Ex. 2035 (U.S. Provisional Application 61/826,446, page 8, Table 8 and page 16) (enhancement of bulk absorption constant)); *see also* '948 Patent at 12:49-55. After considering

W&Wsens' arguments, the Examiner withdrew the § 112(a) rejections in the '948 Divisional "in light of [these] remarks" and granted allowance to the '948 Divisional. Ex. 2034 at 158-159.

Thus, the file history shows that the Office considered these issues and found the Challenged Claims to be enabled, so Petitioners fail to show that it is more likely than not that the '948 Patent claims are not enabled.

IX. CONCLUSION

For all of these reasons, W&Wsens requests that the Board confirm the validity of the Challenged Claims of the '948 Patent.

Respectfully submitted,

Date: May 12, 2026

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CERTIFICATE OF COMPLIANCE WITH 37 C.F.R. § 42.24

The undersigned hereby certifies that the portions of the foregoing **PATENT OWNER'S RESPONSE** has 10,550 words in compliance with the word limit set forth in 37 C.F.R. § 42.24. This word count was prepared using the Microsoft Word word-processing system used to prepare this paper.

Dated: May 12, 2026

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CERTIFICATE OF SERVICE

The undersigned certifies, in accordance with 37 C.F.R. § 42.6(e), and pursuant to agreement by the parties that filing with the Board through the Patent Trial and Appeal Case Tracking System (P-TACTS) constitutes electronic service, that service was made on Petitioners as detailed below.

<i>Date of service</i>	May 12, 2026
<i>Manner of service</i>	Electronic Filing with the Board (joshua.goldberg@finnegan.com; benjamin.saidman@finnegan.com; abhay.watwe@finnegan.com; biju.chandran@finnegan.com; kai.rajan@finnegan.com)
<i>Documents served</i>	PATENT OWNER'S RESPONSE
<i>Persons Served</i>	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP: Joshua L. Goldberg Benjamin A. Saidman Abhay A. Watwe Biju I. Chandran Kai Rajan

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