

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 IPR2025-00993
U.S. Patent No. 12,087,871

PATENT OWNER'S PRELIMINARY RESPONSE

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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 First Supplemental Objections and Responses to Defendants' First Set of Interrogatories (Nos. 1 and 3), <i>W&Wsens Devices, Inc. v. Samsung Elecs. Co.</i> , No. 24-cv-00854-JRG, E.D. Tex., served April 3, 2025
2009	Excerpts from Plaintiff W&Wsens Devices Inc.'s Objections and Responses to Defendants' First Set of Interrogatories (Nos. 1- 3), <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	U.S. Patent Application Publication No. 2011/0309331 ("Yu-331")

Patent Owner's Preliminary Response
IPR2025-00993 (U.S. Patent No. 12,087,871)

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	Excerpt from U.S. District Court – National Judicial Caseload Profile Federal for the Eastern District of Texas
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	Intentionally omitted
2021	U.S. Patent Application Publication No. 2020/0006416 ("Baba")
2022	TechInsight – The state of the art of CMOS Image Sensors, by Ziad Shukri, presented at IISW 2021
2023	PV Education Webpage – Optical Properties of Silicon, available at https://www.pveducation.org/pvcdrom/materials/optical-properties-of-silicon#
2024	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/

Exhibit	Description
2025	Excerpts from “Introduction to Solid State Physics,” by Charles Kittel (7th ed. 1996)
2026	Intentionally omitted
2027	U.S. Patent No. 12,243,948
2028	Excerpts from file history of U.S. Patent No. 12,243,948
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%E2%80%93Lambert_law
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

I. INTRODUCTION

The Board should deny institution of this Petition because the asserted references do not disclose the requisite integrated device having an “array of pillars” and “one or more holes that are deliberately formed into the light-receiving surfaces [of the array of pillars].” These claimed microstructures play a critical role, as “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,” a property that is absent from the asserted art.

Silicon photodetectors have many advantages, including high carrier mobility, mature manufacturing processes, and high quantum efficiencies for photoelectric conversion over most of the visible light range. However, because silicon is relatively transparent to red and infrared light, traditional silicon-based photodetectors struggled to achieve acceptable photoconversion efficiency, especially in dim settings. Ex. 1001 (“the ’871 Patent”) at 2:3-6. One solution to this problem is to increase the thickness of the photodetector, but this solution comes at the cost of decreased bandwidth in telecommunications applications and confounding manufacturing challenges as pixel dimensions continue to shrink. *Id.* at 2:6-8, 2:15-20. To increase the quantum efficiency of silicon photodetectors, W&Wsens invented microstructured pillars and in-pillar holes in thin silicon photodetectors, which dramatically improved their sensitivity in low-light situations.

Kuboi, the primary reference cited against the Challenged Claims (1-4, 6-8, 10-16, and 18) in Grounds 1 and 2, does not disclose an “array of pillars” or “holes that are deliberately formed into the light-receiving surfaces [of the array of pillars]” because it takes an altogether different approach to this problem. Rather than introducing microstructures to enhance the efficiency of a silicon-based photodetector, Kuboi proposes a hybrid photodetector that replaces silicon with semiconducting *organic films* that perform the photoconversion. Although Samsung likens these organic films to the “microstructures” disclosed and claimed in the '871 Patent, they are nothing of the sort. Kuboi's organic film features do not **enhance** a silicon-based photodetector like the microstructured pillars and holes of the '871 Patent do. Instead, Kuboi's organic films themselves perform the photodetection.

Samsung's attempt to combine Yu, Kuboi, and Shinohara in Ground 3 fails because none of the asserted references—individually or in combination—disclose “one or more holes that are deliberately formed into the light-receiving surfaces [of the array of pillars]” that enhance light absorption by at least a factor of 1.1. Yu does not disclose in-pillar holes at all, and instead describes nanopillars without any holes. This was the same conclusion reached when the Office previously considered the substantially similar Yu-331 during prosecution of the '871 Patent and its divisional, and Samsung does not identify any error in the Examiner's analysis.

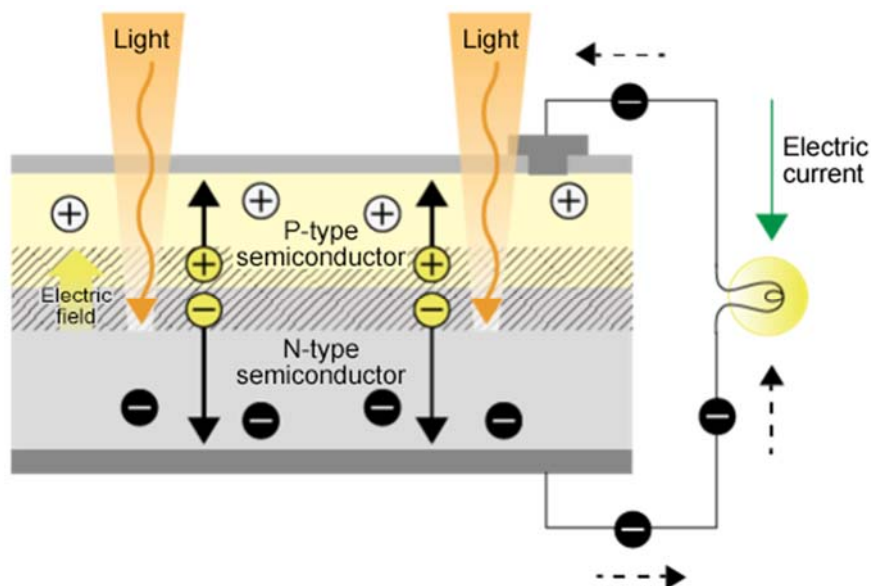
Accordingly, Ground 3 does not present a reasonable likelihood that any claim of the 871 Patent is unpatentable.

Thus, institution should be denied.

II. OVERVIEW

A. There Was a Long-Felt Need to Increase the Sensitivity of Thin-Silicon Photodetectors

There was a long-felt need to increase the effective absorption coefficient of thinner silicon in order to shrink pixels. *See* '871 Patent at 8:17-35. Each pixel in an active-pixel sensor (APS), like a CMOS (Complementary Metal-Oxide-Semiconductor) or CCD (Charge-Coupled Device) sensor, has an array of photodetectors and one or more active transistors. The photodetectors convert light into electricity that can be stored as a signal and read by a computer. These signals measure the amount of light in a scene and, in combination, can be used to create an image. The cells of CMOS sensors are generally made from semiconducting silicon.



Ex. 2024 at 4 (showing schematic of photodiode structure).

To improve device performance, CMOS sensor designers have been increasing pixel count and shrinking individual pixel size so more pixels fit on the sensor and resolution rises. As the distance between adjacent pixels—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.

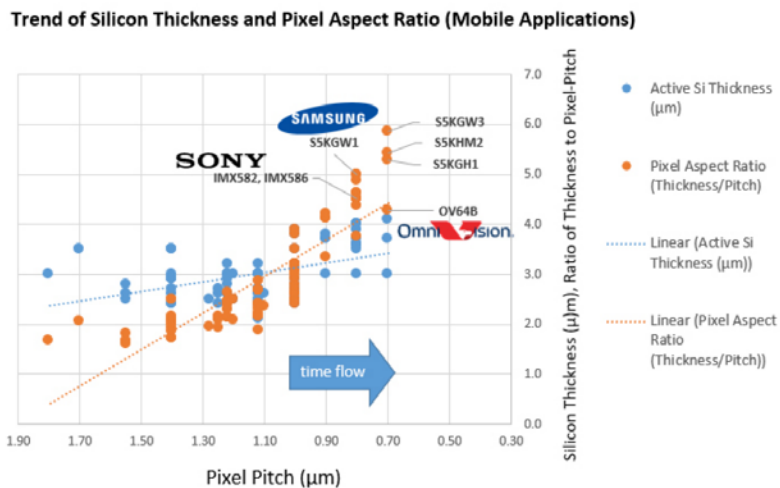
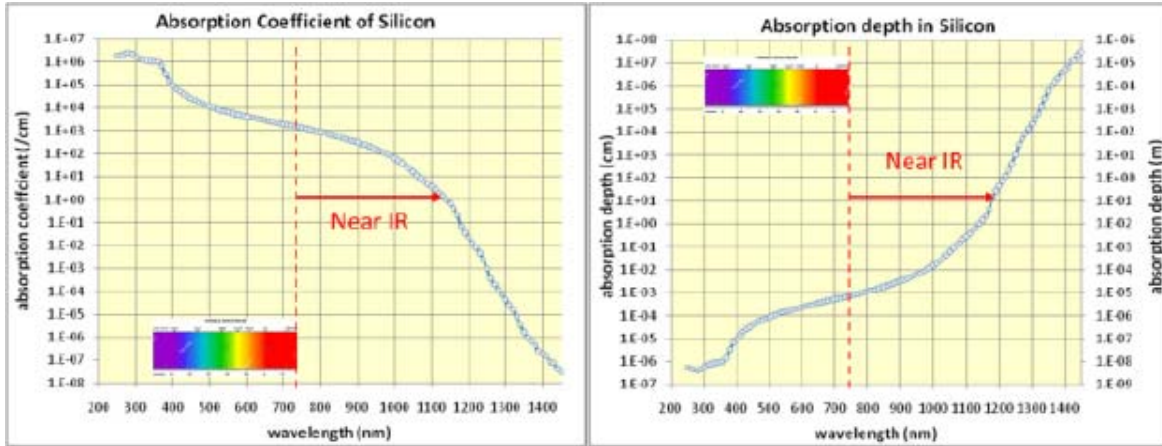


Figure 3 Trend of silicon thickness to pixel pitch ratio.

Ex. 2022 at 8, Fig. 3 (2021 International Image Sensor Workshop by TechInsights) (showing the trend of decreasing pixel pitch and active silicon thickness over time).

Prior to W&Wsens' inventions, these trends had created significant challenges in ensuring sufficient light sensitivity and absorption, particularly once pixel dimensions shrunk to 1 μm and below. Specifically, long-wavelength light (red to infrared) corresponds to silicon's indirect bandgap, which necessitates a relatively thick silicon layer to achieve acceptable sensitivity and absorption. '871 Patent at

2:6-17. For example, for wavelengths longer than 730nm, a thickness of at least $10\mu\text{m}$ of silicon would be necessary to absorb more than 64% of the incident light:



Ex. 2023 at 2-3 (annotations added) (illustrating silicon's decreasing ability to absorb longer wavelength light).

Fabricating silicon devices with such thickness while maintaining the smaller lateral dimensions of the pixels used in higher resolution CMOS sensors in the $1\mu\text{m}$ scale led to difficulties, including lower yield and increased costs for the CMOS sensors. Further reduction in pixel size requires a thinner absorption region, but thinning this region reduces detection efficiency, especially for light with wavelengths in the red to infrared part of the spectrum. Materials other than silicon, such as indium gallium arsenide (InGaAs), are relatively expensive and have high multiplication noise as compared to silicon. '871 Patent at 2:29-31; Ex. 1070 at 7 ("Silicon photode[]tectors 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 long-felt need to increase the effective absorption coefficient of thinner silicon to shrink pixels while increasing photosensitivity. '871 Patent at 1:60-2:31, 8:17-35.

B. The '871 Patent Uses Microstructures to Increase the Sensitivity of Thin-Silicon Photodetectors

To overcome the limitations of conventional silicon CMOS sensors, W&Wsens' inventions use microstructures in the surface of pillars with light-sensitive silicon photodetectors of CMOS sensors. These microstructures, such as pillars and holes, improve the silicon's sensitivity without the need for a thicker silicon absorption layer, which results in telecommunications bandwidths over 10 Gb/s for 850 nm wavelength light and photodetector quantum efficiencies exceeding 90%.¹ '871 Patent, Abstract and 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 the pillars' photosensitive silicon material available to absorb incident light, which would have been expected to reduce light absorption. Yet the '871

¹ “[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.” Ex. 1070 at 25.

Patent's photodetector device ultimately enhances the effective absorption length of the thin silicon because light interacts with the absorbing silicon layers for a longer length of time, which the industry previously achieved by using a thick silicon layer. *Id.* at 8:17-35, 9:4-14. To capitalize on this invention, the '871 Patent claims "an integrated device," such as the "high-speed high efficiency microstructured photodiode 520" of Fig. 5B, which has "an array of pillars" and "one or more holes that are deliberately formed into the light-receiving surfaces [of the array of pillars]," an example of which is depicted in Fig. 49 reproduced below:

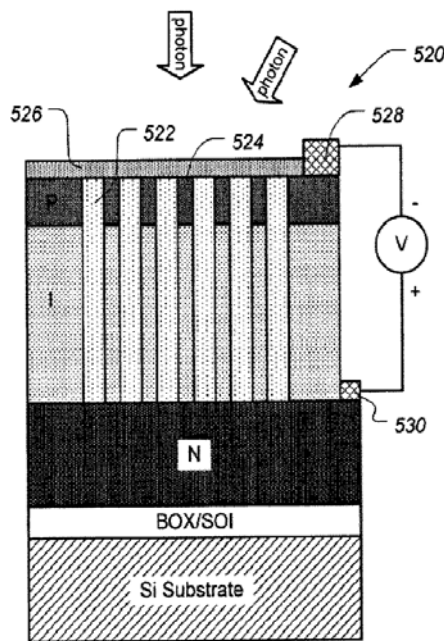


FIG. 5B

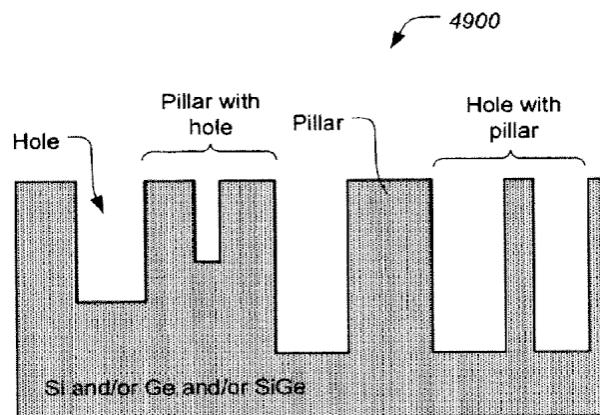


FIG. 49

'871 Patent, Fig. 5B; *see id.* at 55:42-46 (Claim 1), 16:9-59 (explaining embodiment in Fig. 5B), 55:52-56 (Claim 1), Fig. 49 (depicting an example "Pillar with hole"); *see also id.* at 49:57-50:38 (describing microstructured surface of Fig. 49).

This novel structure and arrangement of at least the 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 increases by a factor of at least 1.1 the absorption of the light by [] the photodetectors relative to otherwise like photodetectors lacking said holes.”).

C. The Examiner Found That the Prior Art Lacks In-Pillar Holes

In the '871 Patent's Reasons for Allowance, the Examiner found that the prior art lacks in-pillar holes that improve absorption by a factor of at least 1.1:

[Hsu] fails to disclose the specific characteristic recited in the claims of the instant invention e.g. the combination of claimed limitations of ***an array of pillars and their particular semiconductor material that are configured as photodetectors***, the photodetectors comprise P-I-N doping arrangement, ***holes are formed in the light receiving surfaces of the pillars***, the holes are of a dimension as claimed, side-isolation, solid dielectric material, electrical contacts, ***the holes improve absorption by a particular amount***.

Ex. 1003 at 68 (emphasis added); *id.* (“The prior art fails to disclose the particulars of the holes formed in the light receiving surfaces of the pillars.”). The Examiner explained that Hsu *et al.* (U.S. Patent Application Publication No. 2008/0083963) “shows plural light sensitive pillars, but are lacking the particulars of the holes formed in the pillars, which are then filled with dielectric filling.” *Id.*

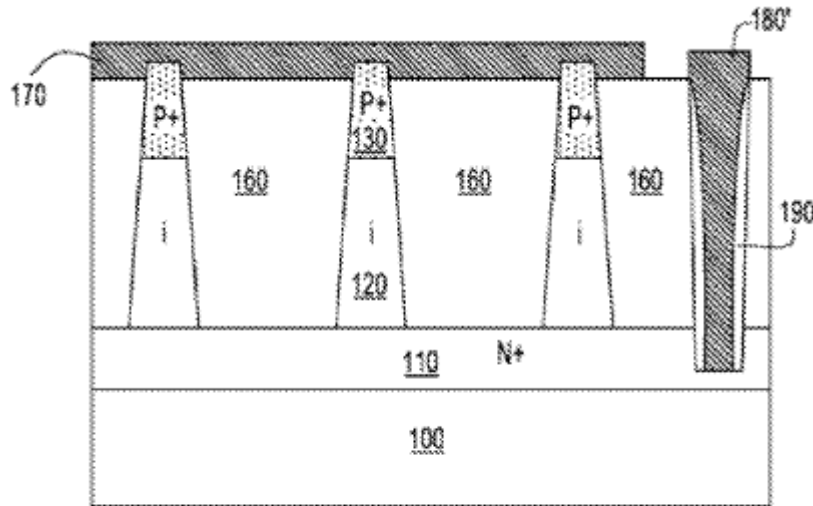


FIG. 3G

Id. (citing Fig. 3G of Hsu).

In his thorough consideration of the prior art, the Examiner reviewed and explained why the '871 Patent was distinguishable over other “[r]elevant [p]rior [a]rt.” *Id.* at 61-63. For example, the Examiner stated that Kuriyama (U.S. Patent Application Publication No. 2004/0157354) similarly “shows plural light sensitive pillars, **but are lacking the holes formed in the pillars with dielectric filling.**” *Id.* at 61 (emphasis added).

FIG. 2A

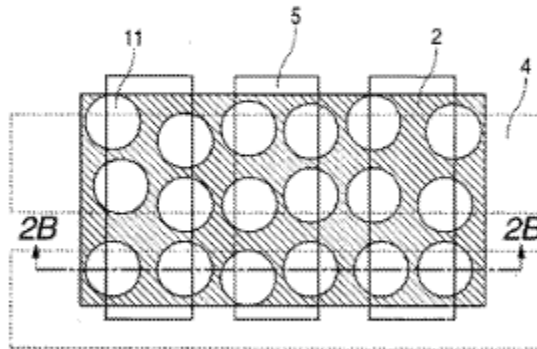
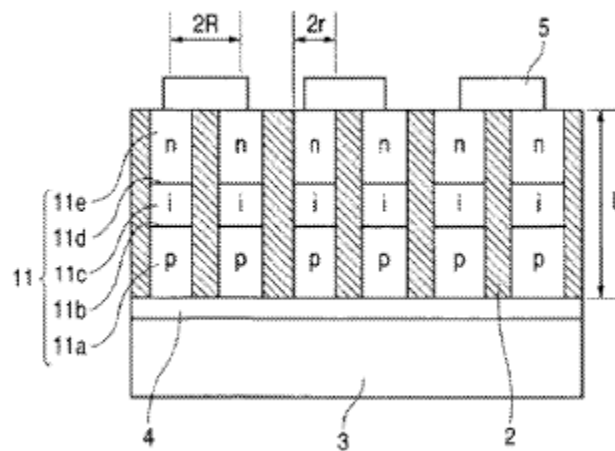


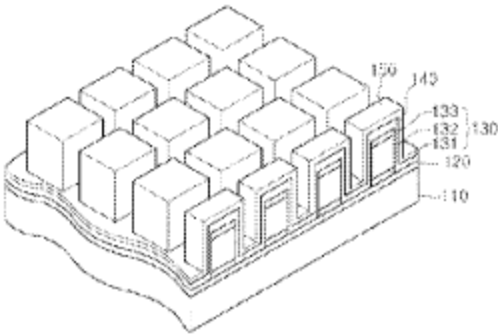
FIG. 2B



Id. at 61 (citing Kuriyama, Figs. 2A, 2B).

The Examiner also cited to Hong (U.S. Patent Application Publication No. 2010/0193022) and explained “[t]his reference shows plural light sensitive pillars, **but are lacking the holes formed in the pillars with dielectric filling.**” Ex. 1003 at 61-62 (emphasis added).

[Fig. 12]



Id. at 61-62 (citing Hong, Fig. 12, [0039]).

In a final example, the Examiner cited to Bandyopahyay (U.S. Patent No. 8,207,064) and noted “[t]his reference shows plural light sensitive pillars, **but are lacking the holes formed in the pillars with dielectric filling.**” Ex. 1003 at 63 (emphasis added).

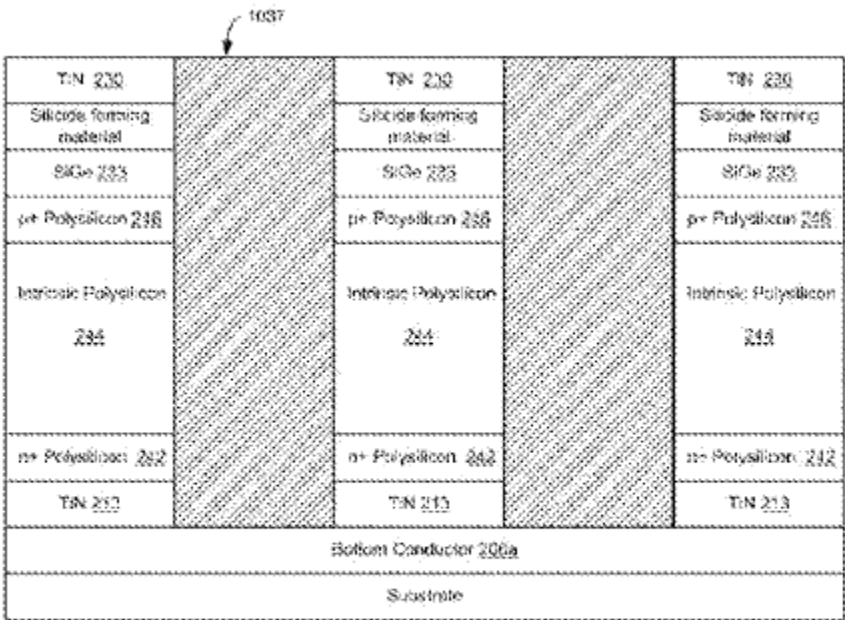


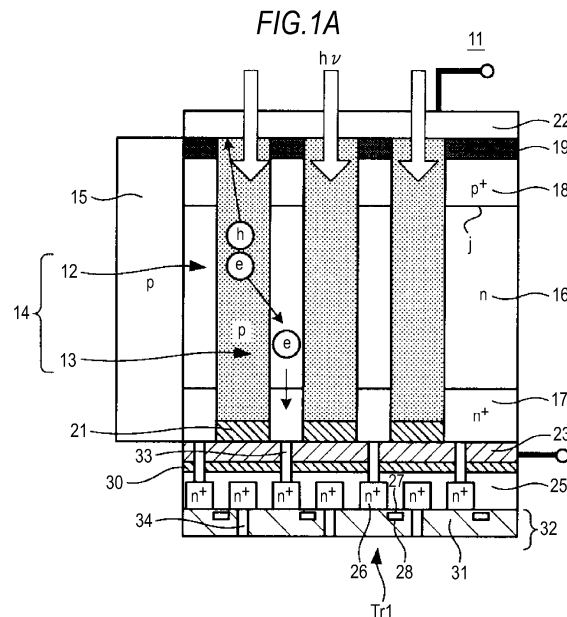
Fig. 10G

Id. at 63 (citing Bandyopahyay, Fig. 10G).

Thus, the Examiner repeatedly distinguished the '871 Patent over the prior art for the Claims' specific recitations of an “array of pillars” and “one or more holes that are deliberately formed into the light-receiving surfaces [of the array of pillars].” As set forth below, Samsung's asserted references in this IPR also lack these key features.

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

Kuboi (Ex. 1004) does not disclose an integrated structure enhanced by microstructures, such as pillars and holes, as is required by the Challenged Claims. It 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].

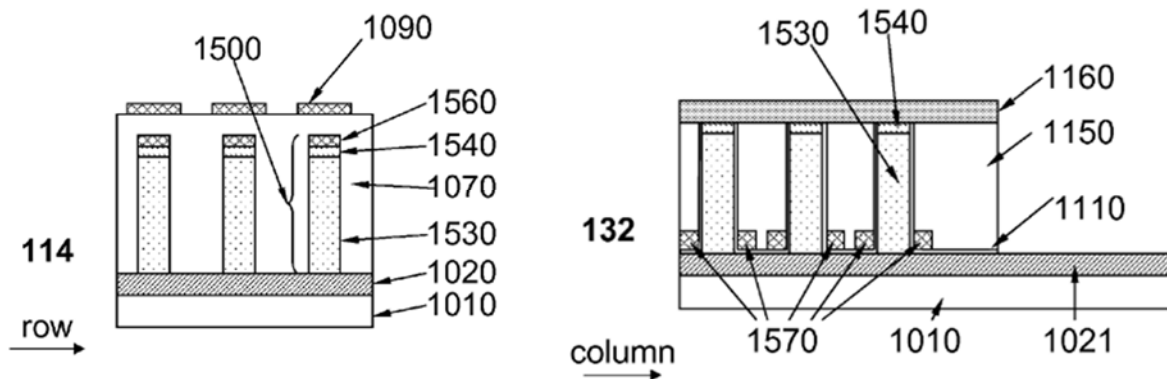


Id., Fig. 1A (showing Kuboi's hybrid structure).

Unlike the photon-absorbing, silicon-based image sensors claimed in the '871 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. *Id.* at [0057]. Accordingly, for reasons described in greater detail below, Kuboi does not disclose a microstructure enhanced photodetector device that absorbs light in 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 deliberately formed into the light-receiving surfaces [of the array of pillars]," to enhance its imaging device.

E. Yu Does Not Describe In-Pillar Holes

Yu (Ex. 1050) does not disclose in-pillar holes (i.e., "one or more holes that are deliberately formed into the light-receiving surfaces [of the array of pillars]"). It is limited to an image sensor with "pixels" that include "at least one nanopillar," but which lacks holes formed in the nanopillars. Yu at Abstract, [0048].



Yu, Fig. 1 at Steps 114 and 132 (showing an image sensor with nanopillars 1500).

The Examiner already considered Yu's teachings during prosecution of the '871 Patent because it is incorporated by reference in U.S. Patent Application Publication No. 2011/0309331 to Yu ("Yu-331", Ex. 2011), which W&W cited to the Office in an IDS. Ex. 1003 at 135, 143 (IDS); *id.* at 100 (Yu-331 considered); Ex. 2011 at [0001] (incorporating Yu by reference); *see* Paper 10 at 17-18 (PO's Request for Discretionary Denial).

The Examiner specifically discussed the shortcomings of Yu/Yu-331 during examination of a related application, which issued as U.S. Patent No. 12,243,948 (Ex. 2027, "'948 Patent").² Ex. 2028 ('948 Patent File History) at 13-14, 24, 28-29 (Yu "20120153124" listed repeatedly in examiner's search history); *id.* at 34, 37 (Yu-331 marked as considered). The '948 Patent's examination is relevant because the claims of the '948 Patent recite limitations similar to those recited in the '871 Patent, including an "array of pillars," "one or more holes . . . at or under the light-receiving surface of each of at least some of the pillars," and a requirement that "the presence of said one or more holes increases by a factor of at least 1.1 the absorption

² The '948 Patent is a divisional of the '871 Patent. Ex. 2027 at cover. The '948 Patent is the subject of Samsung's pending post-grant review petition PGR2025-00082.

of the light by at least some of the photodetectors relative to like photodetectors lacking said holes.” Ex. 2027 at 55:39-42, 55:48-50, 55:64-67.

The Examiner explained that the '948 Patent was patentable over Yu-331 because Yu-331 did not disclose the claimed microstructures:

[T]he prior art of [Yu-331] discloses in Fig. 5 . . . 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 at or under the light receiving surface of at least some of the pillars, 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. 2028 at 6 (emphasis added).

Therefore, the examinations of the '871 Patent and its divisional confirm that the asserted Yu and Yu-331 references fail to disclose “one or more holes that are deliberately formed into the light-receiving surfaces [of the array of pillars]” that increase the light absorption properties of the claimed integrated device.

F. Shinohara Does Not Disclose Microstructures

Samsung does not contend that Shinohara (Ex. 1005) teaches any of the microstructure claim limitations of the Challenged Claims that are missing from

Kuboi and Yu. Shinohara (Ex. 1005) describes an imaging device having a “backside illuminated structure” including “an element isolation region isolating the pixels.” Shinohara at Abstract. Samsung cites Shinohara as allegedly disclosing, among other things, “a base dielectric region.” Pet. at 64-65 (limitation [1e]).

III. SAMSUNG’S CHALLENGE AND ASSERTED REFERENCES

The Petition presents the following grounds:

Ground	Claims	Basis	References
1	1-4, 6-8, 10-16, and 18	§ 103	Kuboi
2	1-4, 6-8, 10-16, and 18	§ 103	Kuboi and Shinohara
3	1-4, 7-8, 15, and 17-18	§ 103	Yu, Kuboi, and Shinohara

Id. at 8.

Although there are a variety of reasons why the ’871 Patent is valid over Kuboi, Yu, and Shinohara, this Preliminary Response focuses on only limited reasons why *inter partes* review should not be instituted. *See Travelocity.com L.P. v. Cronos Techs., LLC*, No. CBM2014-00082, Paper 12 at 10 (P.T.A.B. Oct. 16, 2014) (“[N]othing may be gleaned from the Patent Owner’s challenge or failure to challenge the grounds of unpatentability for any particular reason.”).

IV. LEVEL OF ORDINARY SKILL IN THE ART

For purposes of this Preliminary Response only, W&Wsens adopts Samsung’s definition of a person 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] Additional relevant work experience can compensate for less education, and vice versa.” Pet. at 8.

V. THE CHALLENGED CLAIMS ARE PATENTABLE

A. Kuboi Does Not Disclose an Array of Pillars (Grounds 1-2)

Kuboi does not disclose “an array of pillars . . . configured as photodetectors [that] comprise P-doped and N-doped regions and regions therebetween and ***are configured to respond to illumination with light in selected visible and infrared wavelength ranges by generating electrical charge carriers.***” ’871 Patent at 55:43-51 (emphasis added). The claimed array of pillars must be formed from at least silicon or germanium. *Id.* at 55:43-44 (“array of pillars comprising Si, Ge, and/or SiGe alloy semiconductor material”). Accordingly, the Challenged Claims require silicon/germanium-based photodetectors that have photosensitive semiconductor materials (“P-doped and N-doped regions and regions therebetween”) designed to absorb light and generate electrical output (“electrical charge carriers”).

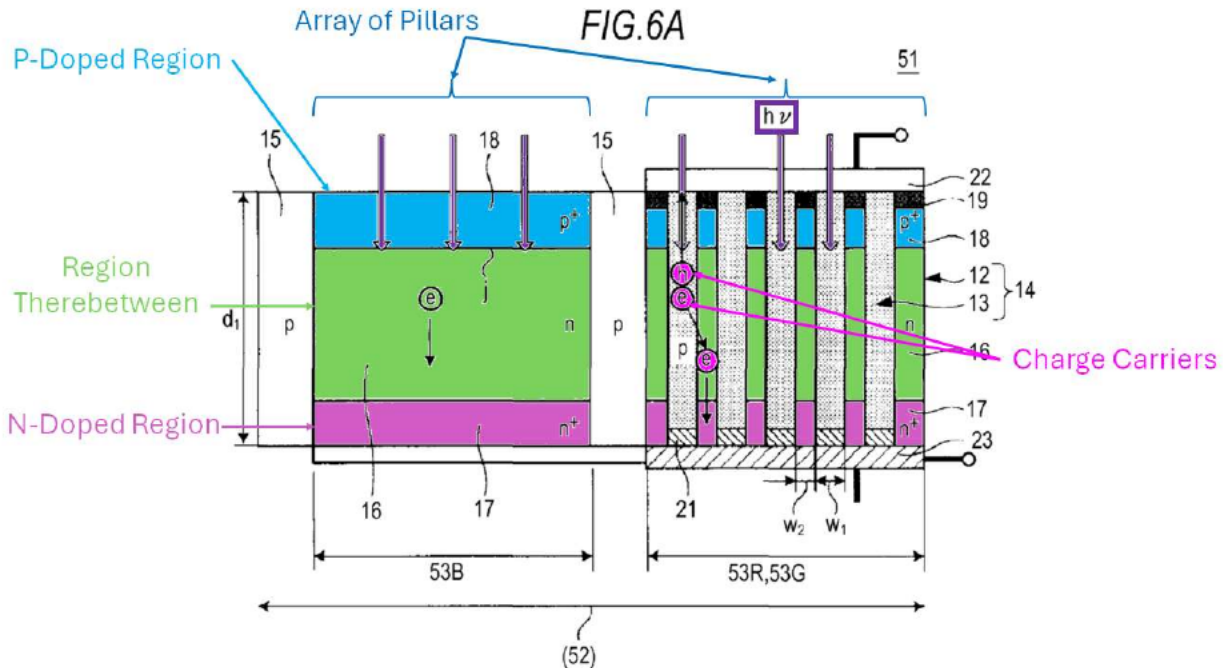
The Challenged Claims’ limitations are fully consistent with the specification, which describes silicon and germanium light absorption regions that generate electrical charge carriers. *Id.* at 3:6-35 (describing “absorbing region and the microstructures comprised of silicon”); *id.* at 3:35-61 (describing “the absorbing

semiconductor region and 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 P-I-N . . . junction area)”).

Kuboi itself distinguishes solid-state imaging devices “having a silicon-based photodiode,” such as those claimed by the '871 Patent, and those “in which an organic material layer is used as the photoelectric conversion portion.” Kuboi at [0002]-[0004]. The '871 Patent claims improvements in the former, and Kuboi is limited to the latter. Specifically, rather than use microstructures to enhance photon absorption in the silicon-based semiconductor layers of the photodetector, Kuboi proposes a “hybrid” photodetector, where electron-hole pairs are generated in organic material layers ***instead of*** the silicon-based semiconductor layers.

The hybrid photoelectric conversion portion is configured so that charges generated in the organic material layers through photoelectric conversion move inside the semiconductor layer so as to be guided to a charge accumulation region.

Kuboi at [0011]. Thus, Kuboi distinguishes its organic material layers, which generate charges, from the semiconductor layer, which guides the charges to the accumulation region. This arrangement is illustrated in Samsung's annotated Kuboi Fig. 6A, where light is incident only on “organic material layers 13”:



Pet. at 20-21 (citing Kuboi, Fig. 6A (annotated)). Kuboi goes so far as to use a “light shielding film 19” on the surface “so that light hv does not enter the semiconductor layer 12,” further confirming that Kuboi’s semiconductor layer 12 does not act as an absorption layer that “respond[s] to illumination with light in selected visible and infrared wavelength ranges by generating electrical charge carriers,” as claimed. Kuboi at [0059], [0064] (“The light hv does not enter the semiconductor layer 12 due to the light shielding film 19.”); ’871 Patent at 55:49-51 (Claim 1).

Kuboi’s imaging device does not, therefore, include photodetectors comprised of “P-doped and N-doped regions and regions therebetween” that are “configured to respond to illumination with light in selected visible and infrared wavelength ranges by generating electrical charge carriers.” Pet. at 19-21. Instead, Kuboi’s “photoelectric conversion films 13” (the alleged microstructure holes) are the

elements that themselves perform photoelectric conversion. Kuboi at [0057] (organic material layers 13 are “where photoelectric conversion is performed”); *id.* at [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].

Accordingly, organic material layers 13 are the active part of Kuboi's photodetector, not the alleged array of pillars of semiconductor material, and the alleged pillars are not “configured” to create “electrical charger carriers” from illumination on light-receiving surfaces of the array of pillars.

B. Kuboi Does Not Disclose the Holes Formed in Pillars (Grounds 1-2)

Kuboi fails to disclose the claimed “one or more holes” formed in pillars, which have the following claimed requirements:

- (1) the holes must enhance light absorption properties of the photodetectors.³

³ '871 Patent at 55:64-67 (“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”).

(2) the holes are formed *into the light-receiving surfaces of the array of pillars*;⁴ and

(3) the holes “are filled at least partly with solid dielectric material.”⁵

'871 Patent at Claim 1. Indeed, the deficiencies in Kuboi are consistent with the Office's stated reasons for allowance that the “prior art fails to disclose the particulars of the holes formed in the light receiving surfaces of the pillars.” Ex. 1003 at 68; *see supra* § II.C.

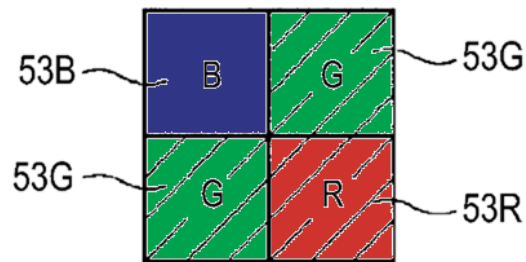
1. Kuboi Does Not Disclose Holes that Enhance Light Absorption of the Photodetectors

Kuboi fails to disclose “one or more holes . . .” that “increase[] . . . the absorption of the light” of the photodetectors. Kuboi discloses an imaging device with “a pixel region 52 in which a group of pixels made up of a blue (B) pixel 53B, a red (R) pixel 53R, a green (G) pixel 53G.” Kuboi at [0090], Figs. 6A, 6B.

⁴ '871 Patent at 55:53-54 (claiming “one or more holes that are deliberately formed into the light-receiving surfaces”); *see also id.* at 55:45-46 (providing antecedent basis for “the light-receiving surfaces” as part of “the array of pillars”).

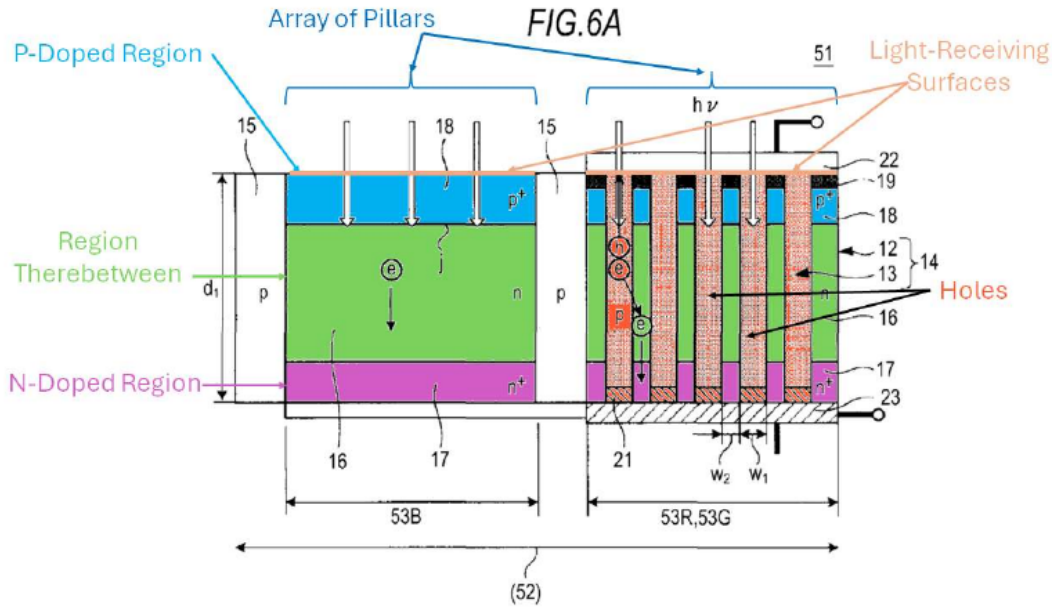
⁵ '871 Patent at 55:55-56.

FIG. 6B



Kuboi, Fig. 6B (annotated); *see* Pet. at 16 (contending that “each pixel constitutes a pillar”).

Kuboi’s pixels do not contain any “holes” formed in pillars that improve performance of the photodetector, as recited in the Challenged Claims. The blue pixel 53B in this array performs conventional silicon-based photoelectric conversion, and the red and green pixels 53R and 53G have the “hybrid photoelectric conversion portion[s]” with organic layers. Kuboi at [0090] (“[B]lue pixel 53B is formed by a photoelectric conversion portion which is formed of a photodiode PD formed in a silicon semiconductor region, and the red pixel 53R, the green pixel 53G, and the green pixel 53G are formed by the hybrid photoelectric conversion portion 14 shown in FIGS. 1A and 1B.”). These two pixel types are shown side by side in Fig. 6A.



Pet. at 26 (citing Kuboi, Fig. 6A (annotated)); *id.* at 22-26 (alleging the “holes 38” of Kuboi constitute holes formed in pillars).

Kuboi’s blue pixel 53B does not include holes or any structures that increase light absorption. Indeed, the Petition does not allege that Kuboi’s blue pixel 53B includes “holes” formed in the pillars. *Id.* at 22-29 (limiting discussion of holes formed in pillars to only the pixel with organic hybrid photoconversion).

Kuboi's red and green pixels operate according to an entirely different principle than Kuboi's blue pixel 53B and the invention claimed in the '871 Patent, as discussed above. *See supra* § V.A. Rather than Kuboi's alleged holes "increas[ing] . . . the absorption of the light by . . . the photodetectors," as recited in the Challenged Claims, Kuboi relies on an entirely different material system with a device that performs photoelectric conversion using organic layers while blocking

light from entering the silicon-based semiconductor layers with a light shielding film

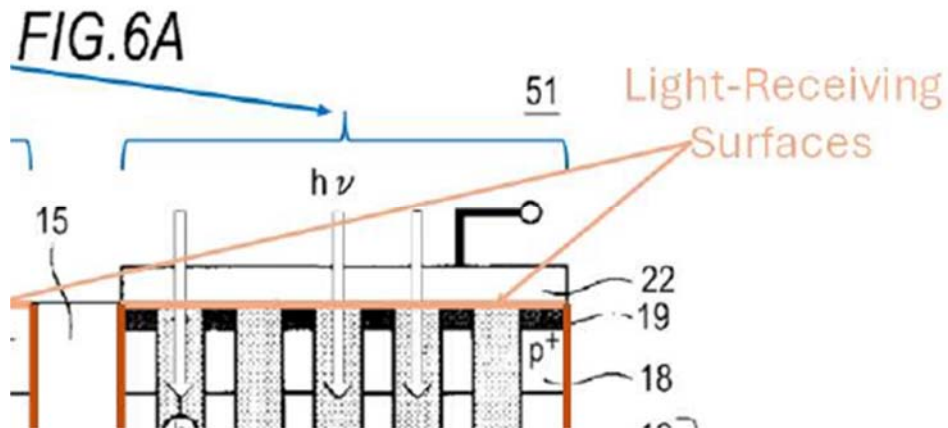
19. Kuboi at [0091].

For these reasons, Kuboi does not disclose any holes formed in pillars that increase the absorption of light on the photodetectors, as required by the Challenged Claims.

2. Kuboi Does Not Disclose Holes That Are Formed into the Light-Receiving Surfaces of the Pillars

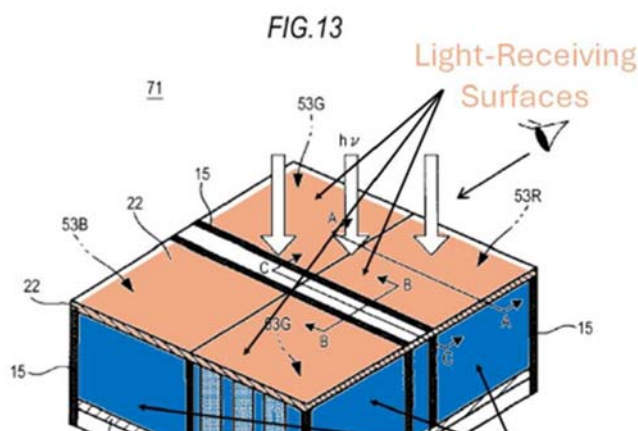
The Board should deny the Petition because Samsung does not identify “with particularity” which elements in Kuboi allegedly disclose “one or more holes that are deliberately formed into the light-receiving surfaces” of the array of pillars. 35 U.S.C. § 312(a)(3). The Petition takes inconsistent positions concerning the location of the “light-receiving surfaces,” and none of those locations satisfy the claims. *See* Pet. at 15-19, 22-25.

First, in discussing limitation [1a], which provides the antecedent basis for the “light-receiving surfaces” in limitation [1c] Samsung points to “the light incident side . . . of Kuboi’s pixels” that is “***located on upper electrode 22’s lower surface.***” Pet. at 16 (arguing “electrode 22 is formed *on* the light incident side”) (emphases added). The lower surface of the upper electrode 22 is cited in Samsung’s annotated Fig. 6A as the light-receiving surface.



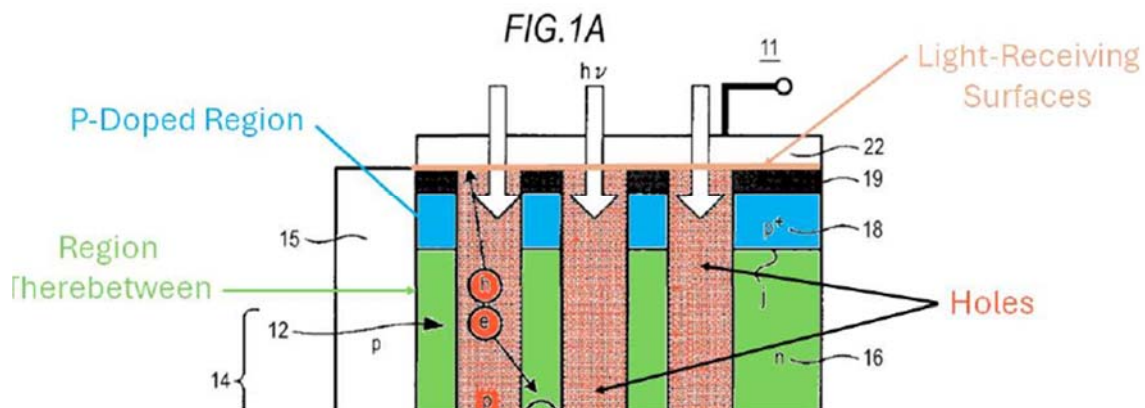
Id. at 18 (citing Kuboi, Fig. 6A, annotated to identify the lower-surface of the upper electrode 22 as the light-receiving surface) (excerpted); *see also id.* at 23 (citing Kuboi, Fig. 1A) (similar); *id.* at 25-26, 28 (same).

Samsung also takes the inconsistent position that **the top surface** of the upper electrode 22 is the claimed “light-receiving surface” when discussing the light “incident on and enters via each pixel’s light-receiving surface” limitation. This is shown in Samsung’s annotation of Fig. 13, reproduced below:



Pet. at 16 (citing Kuboi, Fig. 13, annotated to identify the upper surface of electrode 22 as the light-receiving surface) (excerpted).

Samsung then takes yet another inconsistent position, vaguely alleging that the light-receiving surfaces are “located between region 18 and electrode 22.” Pet. at 25 (citing Fig. 1A). Surfaces “located between” Kuboi’s alleged p-doped region 18 and the upper electrode 22 would be the light-shielding film 19 (depicted in black).

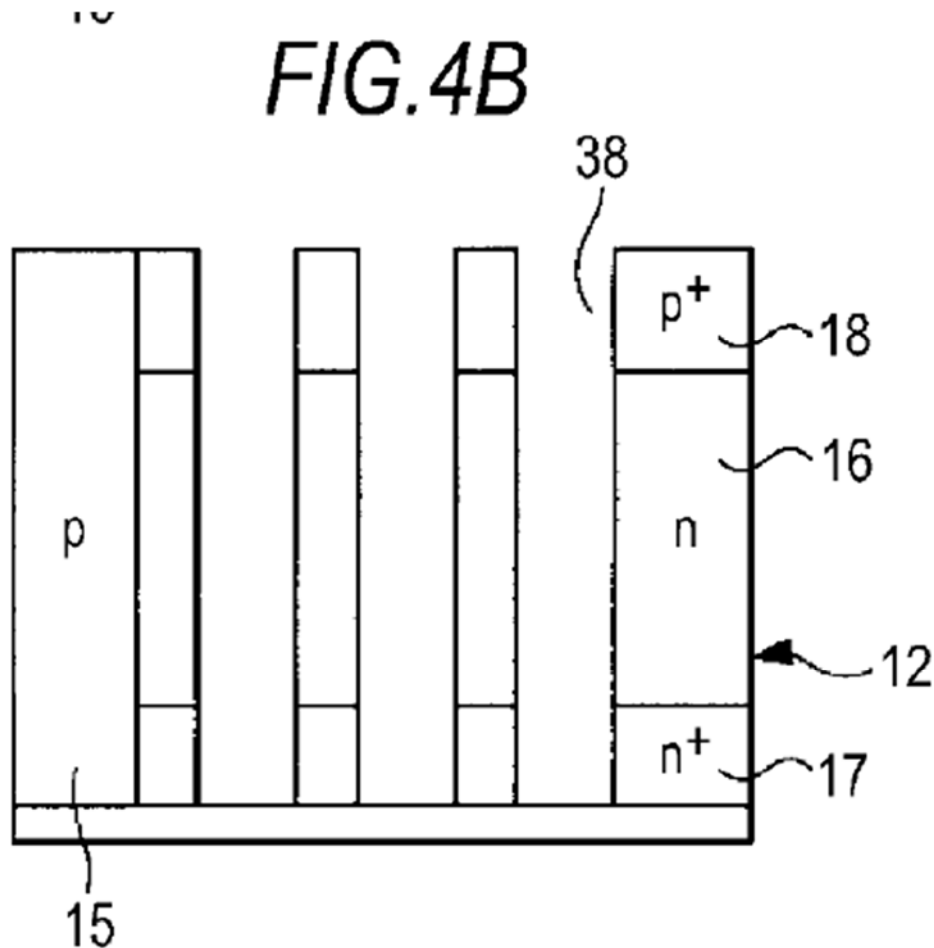


Id. at 24-25 (citing Kuboi, Fig. 1A (annotated)).

Samsung’s inconsistent mapping fails to sufficiently demonstrate that the same element of Kuboi teaches a light-receiving surface of a pillar configured as a photodetector and a light-receiving surface having one or more holes formed therein. *See Western Digital Techs., Inc. v. Godo Kaisha IP Bridge 1*, No. IPR2025-00701, Paper 11 at 17, 20 (P.T.A.B. Oct. 8, 2025) (denying institution where petitioners inconsistently map different structures to the same element across different limitations of the challenged claim).

Samsung’s three inconsistent approaches fail because Kuboi’s alleged holes are actually “formed into” the top of the p-type region, which is not a light-receiving

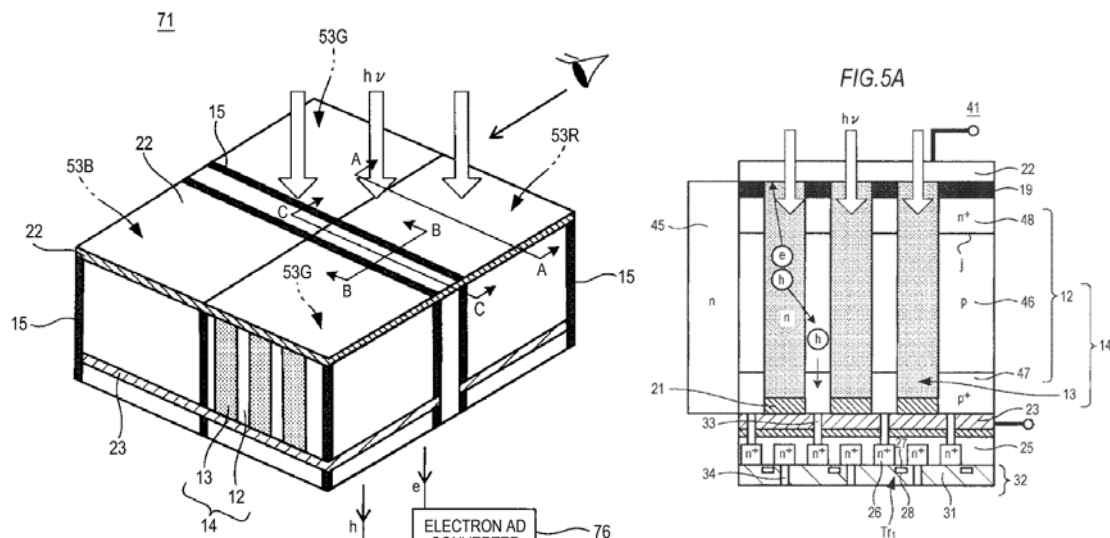
surface. Pet. at 24-25 (citing Lebby Decl. at ¶¶ 124-125). The fabrication details that Dr. Lebby relies on to support his opinion that Kuboi discloses deliberately forming holes in light-receiving surfaces confirm that the relevant openings are dry-etched into the p-type semiconductor region 18:



Kuboi at [0072], Fig. 4B. However, because the upper surface of the p-type region 18 is later covered by light-shielding film 19, which prevents the top surface of the p-type region 18 of the semiconductor layer 12 from receiving any light at all, the top of p-type region 18 is not a light-receiving surface. *Id.* at [0087] (“The light hv

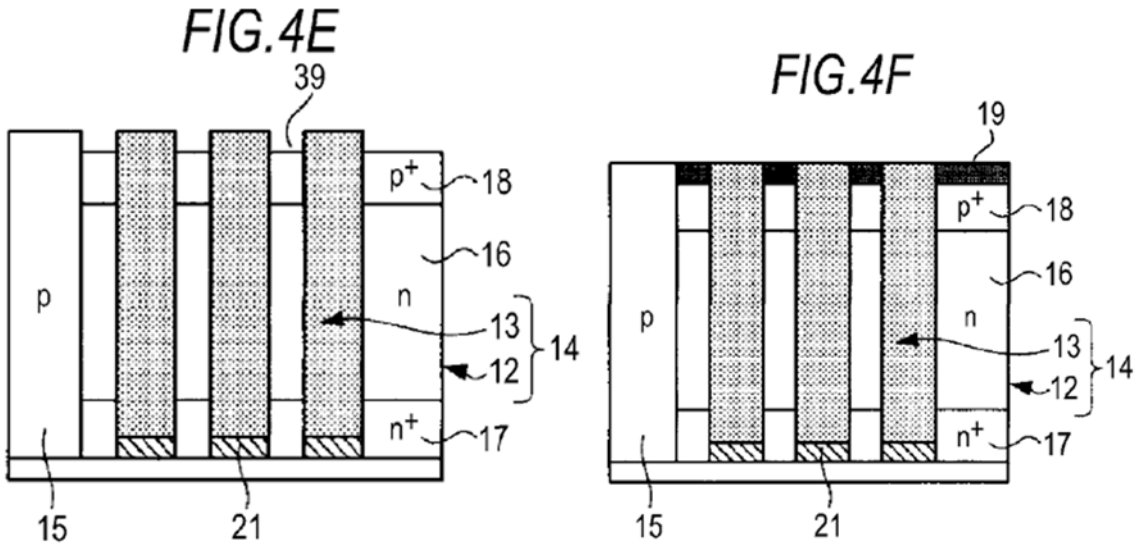
does not enter the semiconductor layer 12 due to the light shielding film 19.”); *see supra* § V.A.

Consistent with this aspect of Kuboi's fabrication process, holes are not “formed into” the upper electrode 22, in its top surface or its lower surface, as Samsung sometimes argues. *See* Pet. at 16-18. As illustrated below, there are no holes formed in any portion of the upper electrode 22:



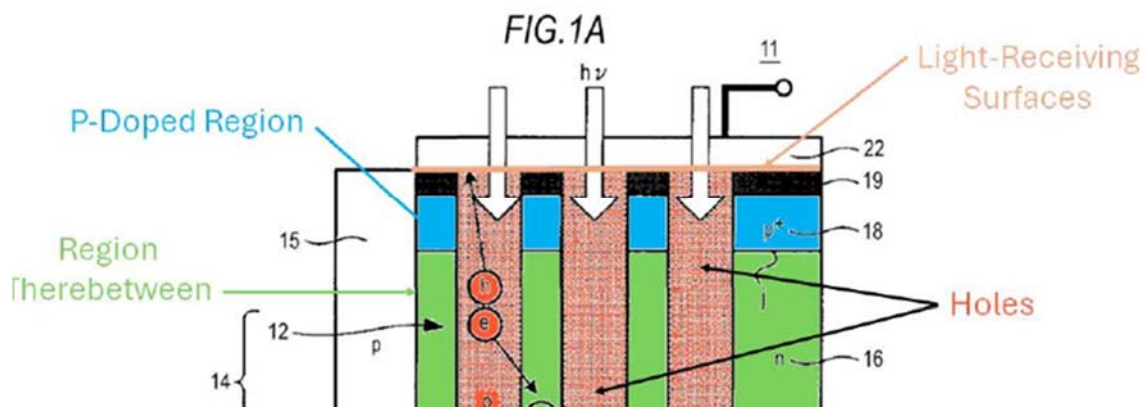
Kuboi, Figs. 13 (excerpted) and 5A (showing a solid electrode with no holes formed in the top surface, middle, or bottom surface of upper electrode 22).

There are also no holes deliberately formed in any locations between the upper electrode and the top of p-type region 18. As disclosed with respect to Figures 4E and 4F, organic material 13 protrudes above the surface of p-type region 18, and light shielding film 19 fills in the concave portions between the films. Kuboi at [0075]-[0076].



Kuboi, Figs. 4E, 4F. Thus, no “holes” are deliberately formed in any region between p-type region 18 and upper electrode 22.

The upper surface of p-type region 18 is also plainly not the “upper electrode 22’s lower surface,” which Samsung sometimes contends is the claimed “light-receiving surface.” Pet. at 16.

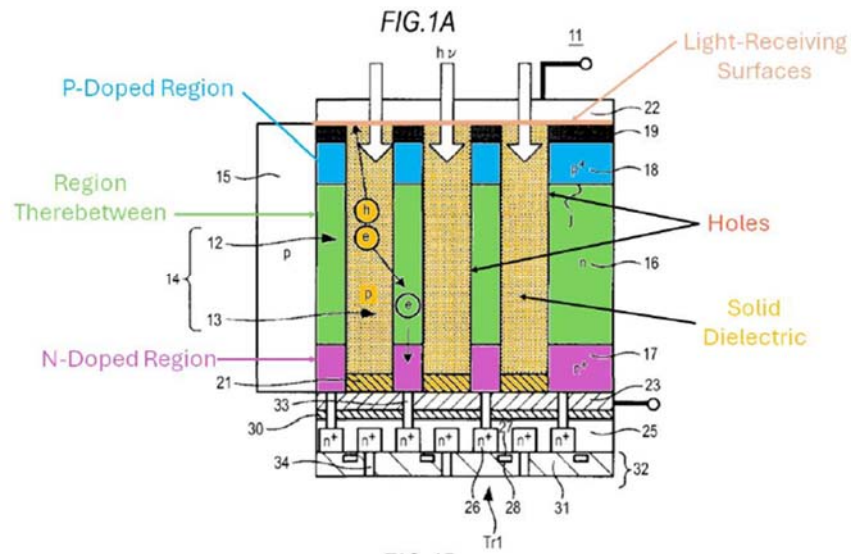


Pet. at 24-25 (annotating Kuboi's Fig. 1A); *see also* Kuboi at [0077] (describing the formation of the upper electrode after alleged holes are etched).

As a result, Kuboi's holes 38 are not holes "deliberately formed into the **light-receiving** surfaces," as required by the Challenged Claims, and Kuboi teaches away from the claimed design.

3. Kuboi Does Not Disclose Holes That are Filled at Least Partly with Solid Dielectric Material

Kuboi also 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 Samsung is incorrect to contend that "electron blocking film 21 and photoelectric conversion film 13 together entirely fill Kuboi's holes and are solid dielectrics." Pet. at 27-28.



Id. at 28 (citing Kuboi, Fig. 1A (annotated)).

First, the requirement that the holes be "filled at least partly with solid dielectric material" ('871 Patent, Claim 1) establishes a fundamental difference from Kuboi, which teaches a thin SiO₂ liner followed by an organic semiconductor bulk

fill. On the other hand, the '871 Patent discloses that partly filling holes with a solid dielectric material, “such as silicon nitride, or silicon oxide,” results in the rest of the hole being filled with air, which has significant benefits to device performance:

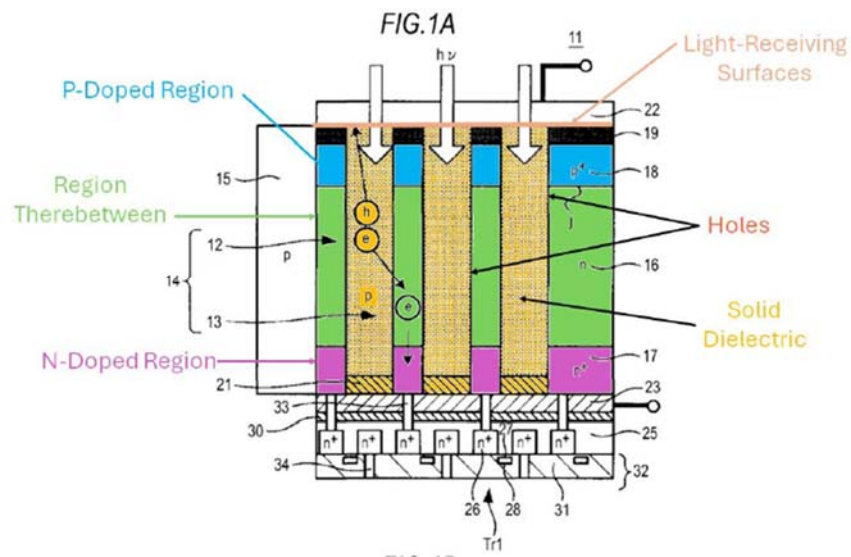
In FIG. 9D a filler 916 is used to ***fill or partially fill the space*** between the Si pillars 914 to support subsequent contact layers to be deposited. The filler 916 can be spin on glass, polyimide, dielectric such as silicon nitride, or silicon oxide, that can be deposited for example using plasma 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.

'871 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 '871 Patent explains that 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.,* '871 Patent at 9:4-14, 9:56-10:5. 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. *Id.* at 19:38-40. Accordingly, while some amount of dielectric filler material is necessary during fabrication, the '871 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 "at least partly" filled with electron blocking film 21. An electron blocking film coats only the bottom of the holes, which are **fully** filled with a semiconducting organic material:



Kuboi at Fig. 1A (annotated) and [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 "at least partly filled with a solid dielectric material," they are fully filled with semiconducting material. *Id.* 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].

Second, because Kuboi's electron blocking film 21 does not at least partly fill holes 38, Samsung takes 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 27-28 (quoting Kuboi at [0058])). They are not.

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"). Samsung's own extrinsic evidence confirms that semiconductors are different from dielectric layers. *See* Ex. 1063 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. 1070 at 22-25 (discussing optical absorption and photogeneration in **semiconductor materials**).

Kuboi also cites to references that establish that organic photoconversion films are **semiconductors**, not dielectric materials. *See, e.g.*, Kuboi at [0005] (citing Ex. 2030 (JP Patent 3423279), “Hiramoto”). 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. Ex. 2030 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 semiconductors, not dielectrics.

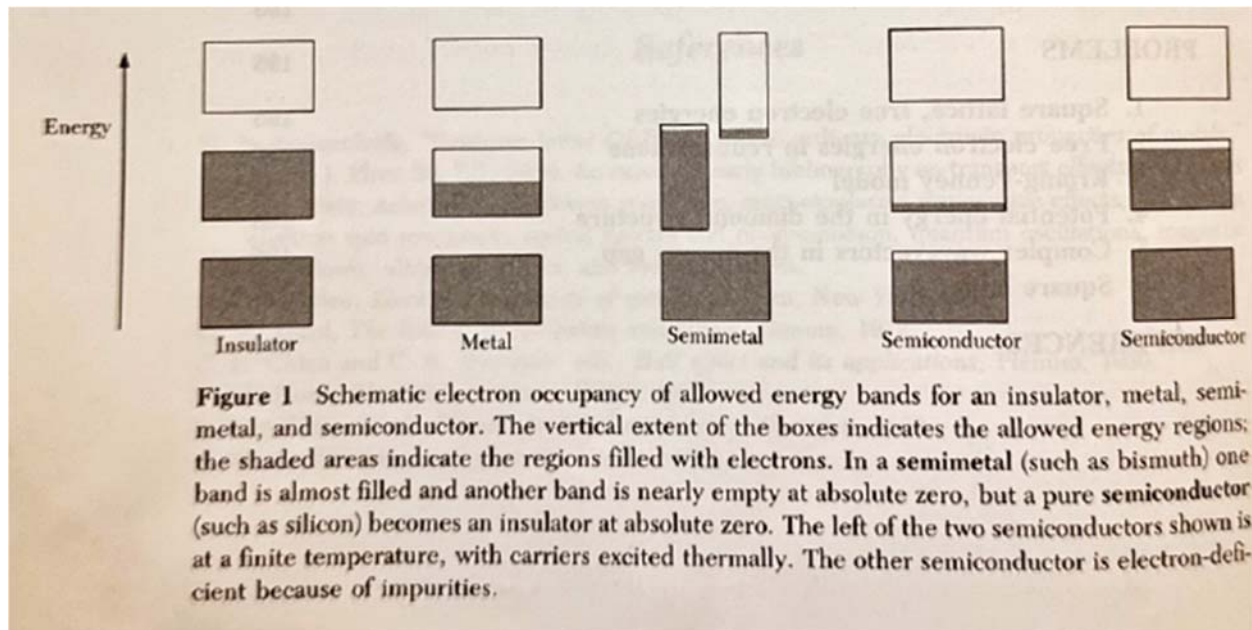
In view of the foregoing, the Board should reject Dr. Lebby’s claim that a “POSITA would have understood that phthalocyanine, perylene-based, and

porphyrin compounds are solid dielectrics” as plainly erroneous and as contradicted by the cited reference itself. Pet. at 28 (citing Lebby Decl., ¶¶ 131-132). Dr. Lebby’s opinion is based on the incorrect notion that any material with a “dielectric constant” or “dielectric properties” is a dielectric material. Ex. 1002, Lebby Decl., ¶ 132. 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 oxide or silicon nitride films are dielectric materials” *because* they are insulators. Ex. 1002, Lebby Decl., ¶ 127.

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

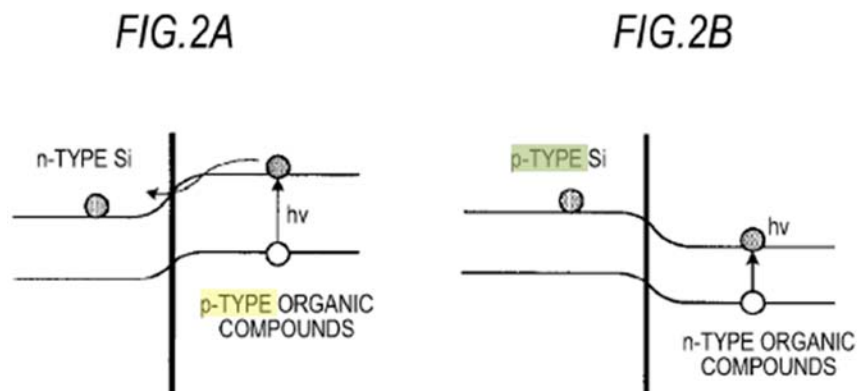
The crystal behaves as an insulator if the allowed energy bands are either filled or empty, for then no electrons can move in an electric field. The crystal behaves as a metal if one or more bands are partly filled, say between 10 and 90 percent filled. The crystal is a semiconductor or semimetal if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

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]. 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").



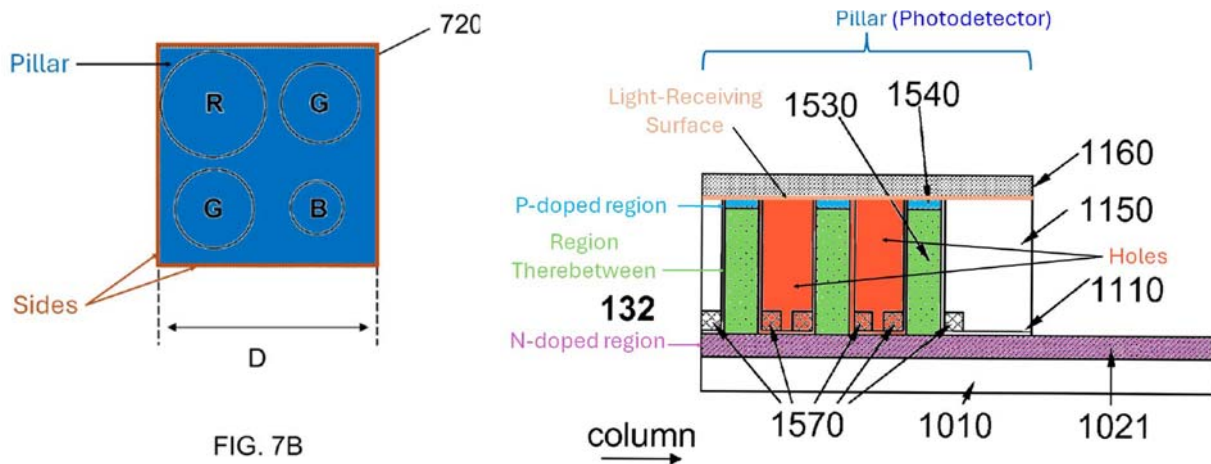
Kuboi, Figs. 2A and 2B (illustrating electron excitation in the band diagram of semiconducting organic compounds, which could not occur in an insulator due to its band structure); *see also, e.g., id.* at [0057] (“In this example, since signal charges are electrons, the organic photoelectric conversion 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.”).

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

C. Yu Does Not Teach or Suggest In-Pillar Holes (Ground 3)

Yu fails to disclose “one or more holes that are deliberately formed into the light-receiving surfaces [of the pillars],” as required by the Challenged Claims. Yu describes an image sensor with “nanopillars,” but those nanopillars have no holes formed therein. Yu at Abstract. This conclusion is consistent with the Examiner’s determination that Yu-331, which incorporates Yu by reference, “fails to disclose the particulars of the holes formed in the light receiving surfaces of the pillars.” Ex. 1003 at 68; *see supra* § II.C.

Because Yu does not disclose holes formed in its “nanopillars,” the Petition makes clear that it does not map these nanopillars to the claimed “array of pillars.” Pet. at 79 (“A POSITA would have understood that Yu’s ‘nanopillars’ are not the claimed pillars.”). Rather, the Petition alleges that Yu’s entire “pixel is the claimed pillar.” *Id.*

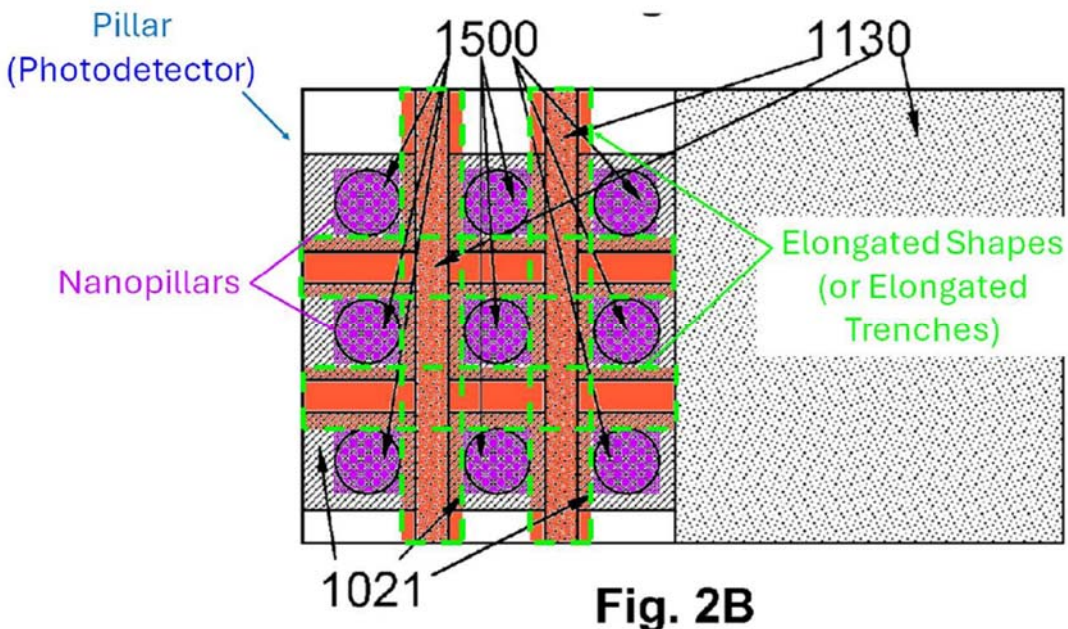


Id. at 81 (citing Yu, Fig. 7B (annotated)); *id.* at 85 (citing Yu, Fig. 1, Step 132 (annotated)).

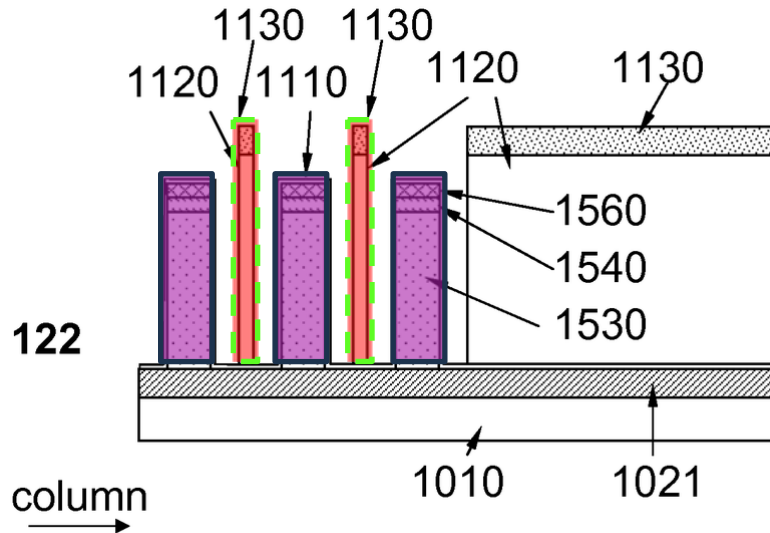
The Board should reject Samsung’s argument that each pixel is a pillar because the only evidence it musters in support of that claim is the conclusory testimony of Dr. Lebby. *See Xerox Corp. v. Bytemark, Inc.*, No. IPR2022-00624, Paper 9 at 15-16 (P.T.A.B. Aug. 24, 2022) (precedential). Dr. Lebby does not even propose any construction for the term “pillar” that Yu allegedly satisfies, he merely labels those areas of Yu’s device as “pillars” without any explanation. Ex. 1002, Lebby Decl., ¶ 233. Samsung has not satisfied the requirement to explain “[h]ow

the construed claim is unpatentable,” including “where each element of the claim is found” in the art. 37 C.F.R. § 42.104(b)(4). Samsung’s argument that “the space[s] between the nanopillar[s]” are the claimed “one or more holes” fails because those spaces are not formed in Yu’s nanopillars (or any other pillars). Pet. at 87; *see also* Yu at [0070] (describing “space between the nanopillars” during step 109 of fabrication).

This argument also fails because Yu’s “space between the nanopillars” are gaps **between** photodetectors rather than holes in the light-receiving surfaces of the pillars:



Pet. at 87 (citing Yu, Fig. 2B (annotated)). Fig. 2B depicts “a top view of the image sensor after step 122.” Yu at [0098]; *see id.* at, Fig. 1, step 122.



Id., Fig. 1, Step 122 (annotated in corresponding colors). The elongated rectangles labelled as element 1130 are patterned mask layers formed on top of the temporary oxide or polymer, and are not holes. Yu at [0083]. Accordingly, as illustrated in the perspective view of Yu-331's Fig. 2A, the alleged "holes" (i.e., the spaces between the nanopillars) do not extend into the nanopillars and are not, therefore, holes formed in the light-receiving surfaces of pillars, as claimed.

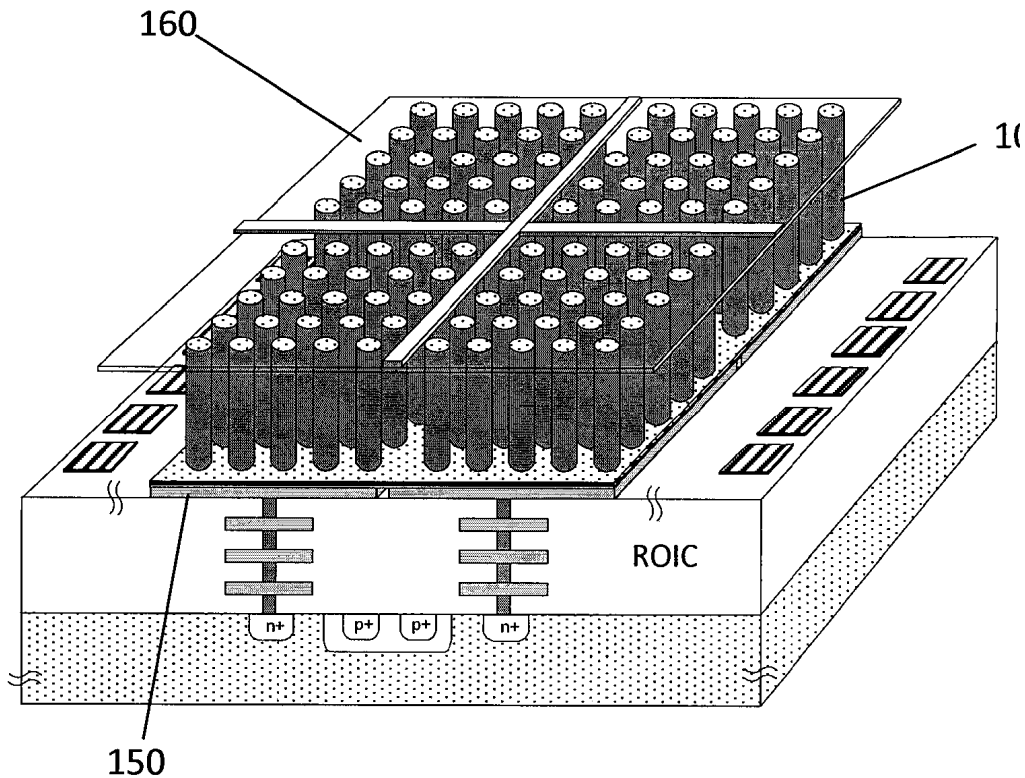


Fig. 2A

Ex. 2011 (Yu-331), Fig. 2A (showing similar image sensor with nanowires similar to Yu's image sensor with nanopillars).

Yu labels each of the nano-pillars areas as R, G, B, in its Fig. 7B, and the areas between these pillars do not detect incident light:

FIG. 7B shows a pixel 720 including four nanopillars R, G, B, G, having different sizes configured to absorb and/or detect red, green, and blue light, respectively, according to an embodiment. Two of the nanopillars, G, absorb and/or detect green light. The diameter of the pixel 720 may be 10 μm or less.

Yu at [0132]. Accordingly, there is no photodetection between the pillars as Samsung labels each pillar a photodetector. Pet. at 81. A photodetector under R is not the same photodetector under G. Thus, Yu does not disclose a photodetector having holes formed in the light-receiving surfaces of a pillar. Each of the independent photodetectors R, G, B disclosed in Yu are accessed by electrodes 1570 and 1021, as shown in Fig. 5.

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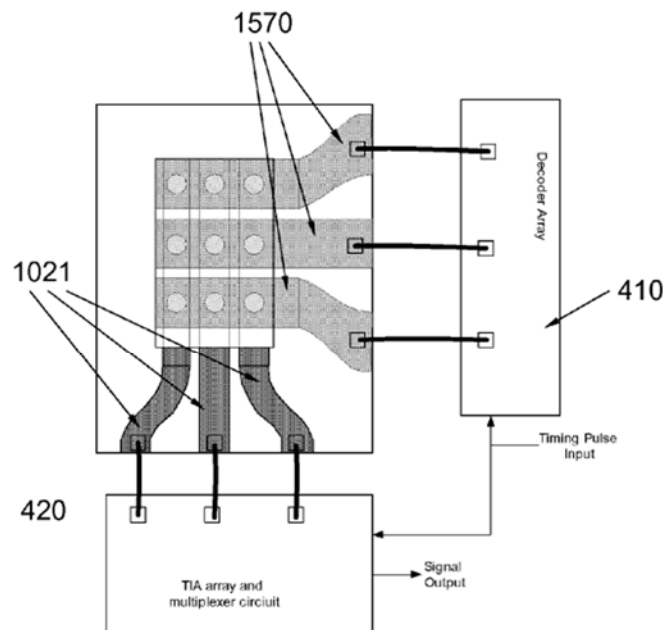


FIG. 5

Yu at Fig. 5.

Accordingly, Yu fails to disclose in-pillar holes and cannot render obvious the Challenged Claims, as confirmed by the Examiner's determination in the May 16, 2024, Notice of Allowance that such structures from Yu lack the claimed holes in pillars. Ex. 1003 at 68; *see supra* § II.C.

D. The Asserted References Do Not Disclose In-Pillar Holes That Increase Light Absorption “By a Factor of At Least 1.1” (Grounds 1-3)

All of the Challenged Claims require that “the presence of [the] 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 [the] holes.” ’871 Patent at 55:64-67 (limitation [1g]). None of the asserted references disclose such structures or an improvement to the light absorption properties of photodetectors because of such structures.

Samsung does not argue that Kuboi or Yu disclose that the presence of alleged in-pillar holes increases light absorption by at least 1.1 times, as the Challenged Claims require. Pet. at 35-36, 91-93. Instead, Samsung tries to substitute for the absence of this disclosure in the reference themselves by relying on thirty pages of expert testimony purporting to estimate an improvement in light absorption from the references’ proposed designs. *Id.* at 35-47 (Grounds 1-2, citing Lebby Decl., ¶¶ 149-175); *see also id.* at 91-96 (Ground 3, citing Lebby Decl., ¶¶ 267-277). Dr. Lebby’s opinions are unreliable and at odds with the record evidence for at least two reasons.

First, Dr. Lebby, who does not claim to have experience with organic semiconductors, uses a facially flawed methodology to attempt to calculate a hypothetical amount of light absorption for Kuboi’s and Yu’s pixels based on the Lambert-Beer Law and a series of assumptions stemming from their pixel

dimensions. Ex. 1002, Lebby Decl. ¶¶ 150-161, 268-272; *see also id.* at ¶¶ 6-29 (describing Dr. Lebby's background). Samsung posits that "[a] POSITA would have understood that the amount of light absorbed by a material of thickness 'd' can be determined using the Lambert-Beer expression as $I_0 (1 - e^{-ad})A$." Pet. at 35. The value "d" in the Lambert-Beer expression refers to the "path length" or the distance that the amount of light travels. Ex. 2031 at 1.

Dr. Lebby's analysis is flawed because he incorrectly assumes that the distance "d" is the depth of Kuboi's holes (1.4 μm). Ex. 1002, Lebby Decl., ¶¶ 134, 150. A POSITA would understand the Lambert-Beer Law is only valid for homogeneous structures, not the type of hybrid structure disclosed in Kuboi. *See* Ex. 2032 at 4 ("Understanding the Limits of Bouger-Beer-Lambert Law") (discussing how, in contrast to a "microhomogenous" material, light "is reflected, leading to scattering" when traveling through a material with "microstructure[s]"); Ex. 2031 at 1 (The Lambert-Beer Law is only appropriate for analyzing light absorption of a "macroscopically homogeneous medium with which [the light] interacts."); *see also id.* at 5 ("There are at least six conditions that need to be fulfilled in order for the Beer-Lambert law **to be valid**. These are: . . . **The attenuating medium must be homogeneous in the interaction volume.**") (emphasis added).

A POSITA would, therefore, understand that simply plugging in the material thickness into the Lambert-Beer expression would not accurately determine the light absorption of Kuboi's hybrid photoelectric conversion portion. *See* Ex. 2032 at 4 (discussing an example microstructure polymer where “***simply determining the absorbance and dividing it by the thickness will not lead to the same result*** as [the Lambert-Beer expression] would imply” because of “scattering” and “reflected” when light “entering and leaving [a] pore”) (emphasis added); *see also* '871 Patent at 8:37-65 (describing “resonance/scattering/near field effects of microstructures”).

Samsung's use of the Lambert-Beer expression is, therefore, invalid because it fails to account for the light scattering and reflection effects of non-homogenous materials in the photodetectors that are the subject of the '871 Patent and the structures in Kuboi and Yu. Other than Dr. Lebby's facially erroneous application of the Lambert-Beer expression, Samsung offers no support for its contention that Kuboi or Yu have structures that increase light absorption, as required.

Second, Samsung cites an external reference Han (Ex. 1051) for its discussion of the alleged “impact of nanoholes on the ultimate efficiency associated with photon absorption.” Pet. at 45-46 (citing Ex. 1051, 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. 1051 at 5:31-33. But Han's graphs do not

concern the efficiency of in-pillar holes because Han does not disclose or suggest the use of in-pillar holes. Samsung offers no explanation for how Han's discussion of the efficiency of its "nanohole arrays" applies to the efficiency of Kuboi's very different hybrid photoelectric conversion portion and organic photoelectric conversion film. Pet. at 45-47.

Therefore, Samsung fails to show that any of its asserted grounds disclose or achieve the claimed improvement in light absorption.

VI. CONCLUSION

For all of these reasons, the W&Wsen requests that the Board deny institution of *inter partes* review of the Challenged Claims of the '871 Patent.

Respectfully submitted,

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

The undersigned hereby certifies that the portions of the above-captioned **PATENT OWNER'S PRELIMINARY RESPONSE** specified in 37 C.F.R. § 42.24 has 7,540 words in compliance with the 14,000 word limit set forth in 37 C.F.R. § 42.24(b)(1). This word count was prepared using the Microsoft Word word-processing system used to prepare this paper.

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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.

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