

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 IPR2025-00996
U.S. Patent No. 10,446,700

PATENT OWNER'S PRELIMINARY RESPONSE

TABLE OF CONTENTS

	Page
I. INTRODUCTION	1
II. OVERVIEW	2
A. There Was a Long-Felt Need to Increase the Sensitivity of Thin-Silicon Photodetectors	2
B. The ’700 Patent Uses Microstructures to Increase the Sensitivity of Thin-Silicon Photodetectors.....	6
C. Kuboi Teaches a Hybrid Structure Where Organic Layers Absorb the Incident Light, Not a Microstructure-Enhanced Photodiode (MSPD)	8
III. SAMSUNG’S PROPOSED UNPATENTABILITY GROUNDS	9
IV. LEVEL OF ORDINARY SKILL IN THE ART	9
V. THE CHALLENGED CLAIMS ARE PATENTABLE BECAUSE KUBOI FAILS TO TEACH OR SUGGEST A “MICROSTRUCTURE-ENHANCED PHOTODETECTOR (MSPD)”	10
VI. CONCLUSION.....	14

TABLE OF AUTHORITIES

	Page(s)
Cases	
<i>Travelocity.com L.P. v. Cronos Techs., LLC</i> , No. CBM2014-00082, Paper 12 (P.T.A.B. Oct. 16, 2014,)	2

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	Complaint for Patent Infringement, <i>W&Wsens Devices, Inc. v. Samsung Elecs. Co.</i> , No. 24-cv-00854-JRG, Dkt. No. 1 (E.D. Tex. Oct. 21, 2024)

Patent Owner's Preliminary Response
IPR2025-00996 (U.S. Patent No. 10,446,700)

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. 56 (E.D. Tex. April 24, 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, available at https://www.uscourts.gov/sites/default/files/202412/fcms_na_distprofile0930.2024.pdf
2017	Excerpts from Defendants' Invalidity Contentions cover pleading, <i>W&Wsens Devices, Inc. v. Samsung Elecs. Co.</i> , No. 24-cv-00854-JRG, E.D. Tex., served May 2, 2025
2018	U.S. Patent No. 10,622,498
2019	U.S. Patent No. 9,530,905
2020	W&Wsens Devices Inc. presentation – Time-of-Flight Solutions For The Next Generation
2021	Tech Times webpage - Three types of photodiodes and their structures and operating principles, available at https://techtimes.dexerials.jp/en/photonics/three-types-of-photodiodes/
2022	TechInsight - The state of the art of CMOS Image Sensors, presented at IISW 2021

Patent Owner's Preliminary Response
IPR2025-00996 (U.S. Patent No. 10,446,700)

Exhibit	Description
2023	PV Education webpage – Optical Properties of Silicon, available at https://www.pveducation.org/pvcdrom/materials/optical-properties-of-silicon#

I. INTRODUCTION

Patent Owner W&Wsens Devices Inc. respectfully requests that the Board deny institution on the Petition because Kuboi fails to teach or suggest a microstructure-enhanced photodetector (MSPD), as recited in each of the Challenged Claims.

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. U.S. Patent No. 10,446,700 (Ex. 1001, “the ’700 Patent”) at 2:62-65. 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 manufacturing challenges as pixel dimensions continue to shrink. *Id.* at 2:62-3:6. To increase the quantum efficiency of silicon photodetectors, W&Wsens invented microstructured holes in thin silicon photodetectors, which dramatically improved their sensitivity in low-light situations.

Kuboi, the only reference cited against the Challenged Claims (1-4, 7, 9-12, 16-17, 20-21, 24-26, 28-30, 32, and 35) cannot teach or suggest a microstructure-enhanced photodetector (MSPD) because it takes an altogether different approach to

this problem. Rather than introducing microstructures to enhance the efficiency of a photodetector, Kuboi proposes a hybrid photodetector that replaces silicon with **organic films** that perform the photoconversion. Although Petitioners liken these organic films to the “microstructures” disclosed and claimed in the '700 Patent, they are nothing of the sort. Kuboi's organic film features do not enhance a photodetector like the microstructured holes of the '700 Patent do. Instead, Kuboi's organic films actually perform the photodetection.

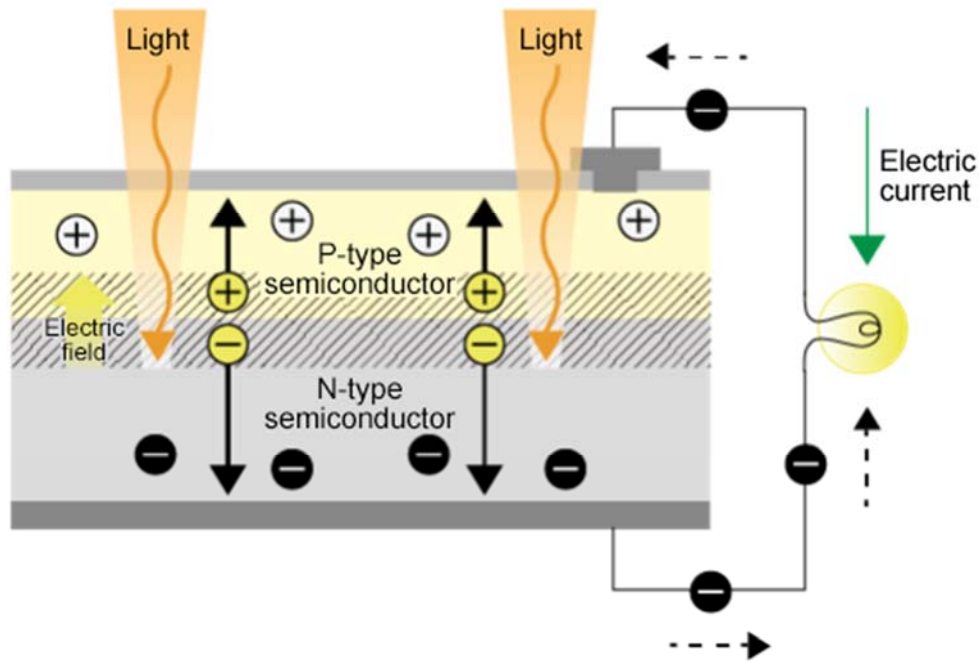
Although there are a variety of reasons why the '700 Patent is valid over Kuboi, this Preliminary Response focuses on only limited reasons why *inter partes* review should not be instituted. See *Travelocity.com L.P. v. Cronos Techs., LLC*, No. CBM2014-00082, Paper 12 at 10 (P.T.A.B. Oct. 16, 2014) (“[N]othing may be gleaned from the Patent Owner's challenge or failure to challenge the grounds of unpatentability for any particular reason.”).

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 absorption coefficient of thinner silicon to shrink pixels. Each pixel in an active-pixel sensor (APS), like a CMOS or CCD 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 the CMOS sensors are generally made from semiconducting silicon.



Ex. 2021 at 4 (showing schematic of photodiode structure).

To increase device performance, there is a trend in CMOS sensor design to increase resolution (number of pixels) and to reduce pixel size. This has led to an increase in active silicon thickness with decreased pixel pitch, referring to the distance between pixels.

Trend of Silicon Thickness and Pixel Aspect Ratio (Mobile Applications)

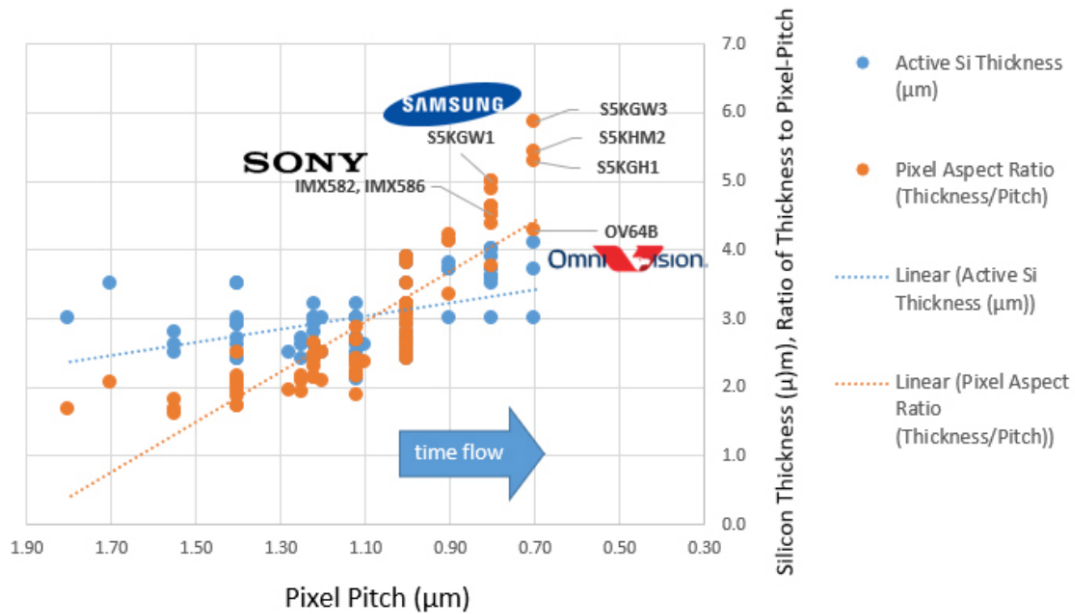
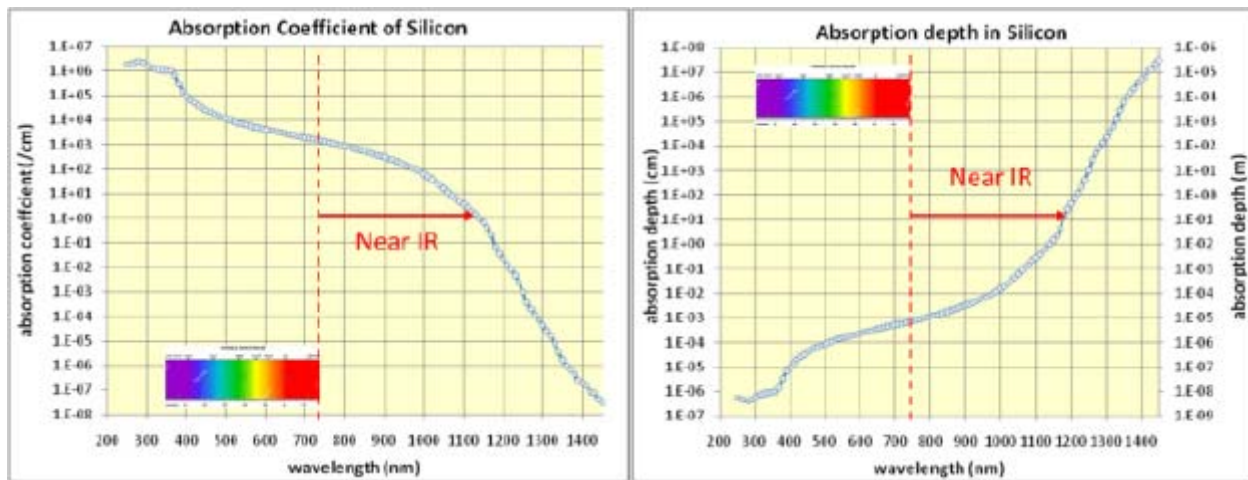


Figure 3 Trend of silicon thickness to pixel pitch ratio.

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

Prior to W&Wsens' inventions, this trend had created significant challenges in ensuring sufficient light sensitivity and absorption, particularly when pixel dimensions shrunk to 1μm or 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. '700 Patent at 2:62-3:6. For example, for wavelengths longer than 730nm, a thickness of at least 10μm 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 μ m scale has 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 more expensive and are difficult to integrate with silicon-based electronics as a single chip. '700 Patent at 3:18-21.

Thus, there was a long-felt need to increase the absorption coefficient of thinner silicon to shrink pixels while maintaining or even increasing photodetection

sensitivity, including for infrared applications such as low-light photography, depth detection, and facial recognition. *Id.* at 3:32-43.

B. The '700 Patent Uses Microstructures to Increase the Sensitivity of Thin-Silicon Photodetectors

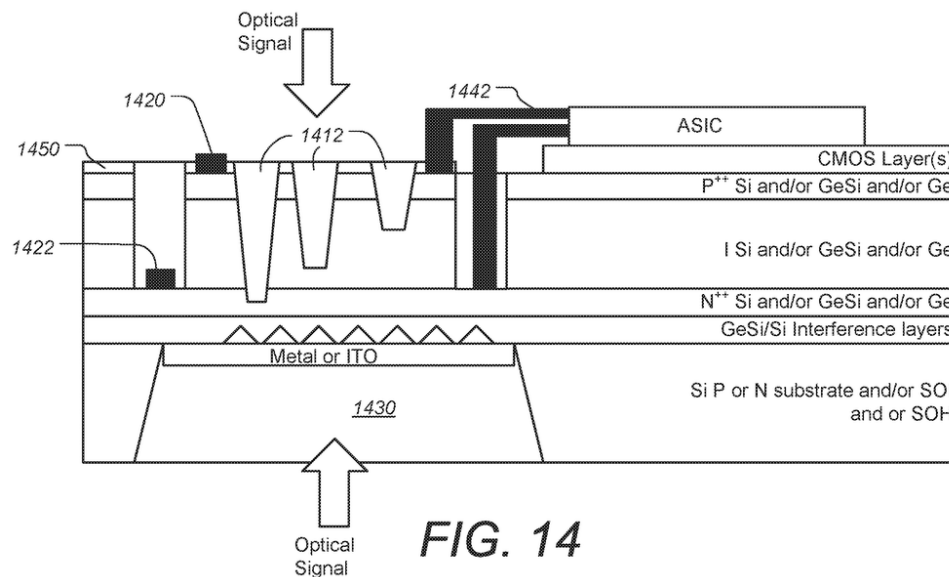
In order to avoid the conventional limitations of silicon in CMOS sensors, W&Wsens' inventions use microstructures in the surface of light-sensitive silicon photodetectors of CMOS sensors. These microstructures trap photons and improve the silicon's sensitivity without the need for a thicker silicon absorption layer.

The '700 Patent discloses microstructure-enhanced photodiodes and avalanche photodiodes that are monolithically integrated with CMOS circuitry. '700 Patent, Abstract. The inventors realized that microstructures, such as holes, can improve photoconversion efficiency in silicon and III-V materials over a similar structure without microstructures for enhancement of the absorption over a given wavelength range and can also reduce avalanche voltages for avalanche photodiodes. *Id.*, Abstract and 15:41-49.

This result is counterintuitive because the presence of holes reduces the amount of photosensitive silicon material to absorb the light, which would have been expected to reduce light absorption. Yet the '700 Patent's MSPD device ultimately enhances the effective absorption length of the thin silicon because light is able to

interact with absorbing layers for a longer length of time, which is equivalent to a thicker silicon layer. *Id.* at 15:46-49.

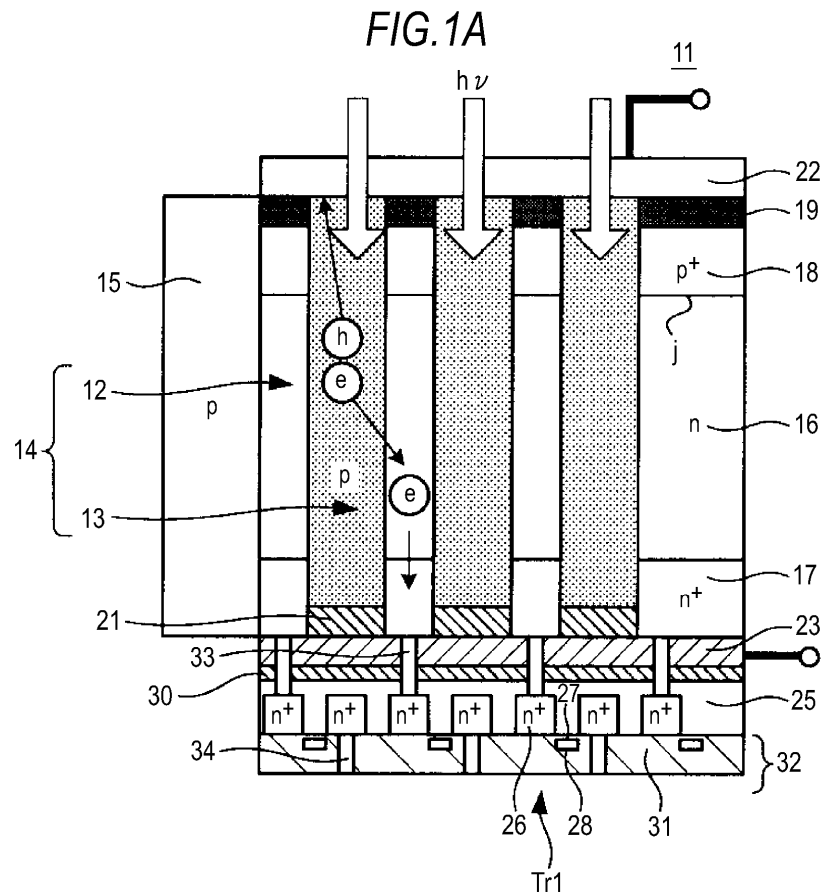
To capitalize on this invention, the '700 Patent claims a single-chip device, including an integrated combination of “a microstructure-enhanced photodetector (MSPD) and an active electronic circuit, both formed on or in a single substrate.” '700 Patent at 4:60-63. Because the photodetector is formed from silicon or a silicon alloy, the photodetector can be easily integrated into a single chip with other silicon-based active circuitry. *Id.* at 20:12-20, 20:33-36, 110:13-15, 39:33-50



Id., Fig. 14 (illustrating a photodetector integrated with an application specific integrated circuit on a single chip). On the other hand, while other material systems like InGaAs can efficiently detect light at longer wavelengths, they are very difficult to integrate with other silicon-based electronics. *Id.* at 3:7-21.

C. Kuboi Teaches a Hybrid Structure Where Organic Layers Absorb the Incident Light, Not a Microstructure-Enhanced Photodiode (MSPD)

Kuboi (Ex. 1004) does not disclose a microstructure-enhanced photodiode (MSPD). It is directed to a “solid-state imaging device.” Kuboi at [0001]. This device includes photodetectors with a “hybrid photoelectric conversion portion 14” including “organic material layers 13” embedded in a silicon “semiconductor layer 12.” *Id.* at [0055].



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

Unlike the photon-absorbing, silicon-based image sensors claimed by the '700 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, Kuboi does not disclose a microstructure enhanced imaging device, because it does not utilize any "microstructures" to enhance its imaging device, for reasons described in greater detail below.

III. SAMSUNG'S PROPOSED UNPATENTABILITY GROUNDS

The Petition presents the following grounds for challenging various claims of the '700 Patent.

Ground	Claims	Basis	Reference Relied Upon
1A	1-4, 7, 9-12, 16-17, 20-21, 24-26, 28-30, 32, and 35	§ 102	Kuboi
1B	1-4, 7, 9-12, 16-17, 20-21, 24-26, 28-30, 32, and 35	§ 103	Kuboi

Pet. at 8. Samsung asserts that the Challenged Claims are entitled to a priority date of May 22, 2013, at least for the purposes of this proceeding. *Id.* at 7.

IV. LEVEL OF ORDINARY SKILL IN THE ART

For purposes of this Preliminary Response, W&Wsens applies 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 five 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 BECAUSE KUBOI FAILS TO TEACH OR SUGGEST A “MICROSTRUCTURE-ENHANCED PHOTODETECTOR (MSPD)”

Kuboi does not teach or suggest the claimed “microstructure-enhanced photodetector (MSPD);” it teaches a hybrid semiconductor/organic photodetector. ’700 Patent, Claim 1. Kuboi itself distinguishes solid-state imaging devices “having a silicon based photodiode,” such as those claimed by the ’700 Patent, and those “in which an organic material layer is used as the photoelectric conversion portion.” Kuboi at [0002]-[0004]. The ’700 Patent claims the former, and Kuboi is limited to the latter. Thus, Kuboi’s organic material films, which Petitioners contend are “microstructures,” do not *enhance* a photodetector, they *are* the photo detecting regions in Kuboi’s device.

The claimed photodetector must be formed from silicon, germanium, or a silicon-germanium alloy . According to the express language of the Challenged Claims, the MSPD includes three semiconductor layers formed of “Silicon, Germanium, or an alloy thereof,” and reverse-bias contacts that “sweep in a selected direction electrical charges *generated in the MSPD.*” ’700 Patent, Claim 1

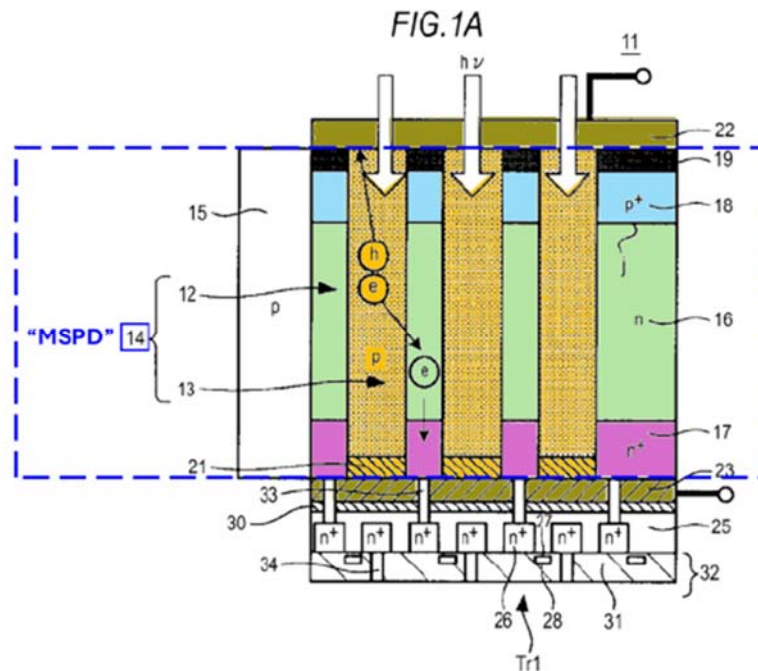
(emphasis added). Accordingly, the '700 Patent discloses a semiconductor-based photodetector that has photosensitive semiconductor layers designed to absorb optical input (light) and generate electrical output. *Id.* at 17:54-64; 118:56-57.

The Challenged Claims require “microstructures” that enhance a photodetector. '700 Patent, Claim 1 (reciting a microstructure-enhanced photodetector). This is consistent with the specification, which explains that these microstructures “can enhance the absorption of incident signal photons and can result in a larger external quantum efficiency over a similar structure without microstructures for enhancement of the absorption over a given wavelength range.” *Id.* at 15:41-46. These “microstructures, such as holes” enhance “photon trapping” and permit “[l]ight [to] interact with absorbing layer(s) for a longer length of time.” *Id.* at Abstract, 15:47-49, 21:40-43. Thus, the plain language of the claims requires that the microstructures enhance the photon absorption of the photodetector.

Kuboi proposes a different solution to the problem of inefficient photodetection of longer wavelength light in thin semiconductor-based devices. Kuboi at [0006]. Rather than introduce microstructures to enhance photon absorption in the semiconductor layers of the photodetector, Kuboi proposes a “hybrid” photodetector, where electron-hole pairs are generated in organic material layers ***instead of*** the 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]. This arrangement is illustrated in Petitioners' annotated version of Kuboi's Fig. 1A, where light is incident only on "organic material layers 13":



Pet. at 12-13 (citing Kuboi, Fig. 1A (annotated)). Kuboi goes so far as to use a "light shielding film 19" on the surface "so 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.").

Kuboi's imaging device is not, therefore, a microstructure-enhanced photodetector because there is no microstructure that enhances the photodetector. Instead, Kuboi's "photoelectric conversion films 13" (the alleged microstructures) are the elements that themselves perform photoelectric conversion. Pet. at 18; Kuboi at [0057] (organic material layers 13 are "where photoelectric conversion is performed"); Kuboi 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]. As such, organic material layers 13 are the active part of Kuboi's photodetector, not an enhancement to it.

This fundamental flaw in the Petition is demonstrated by its circular logic, which claims that: "[e]tching vertical holes 38 and embedding photoelectric conversion films 13 in photoelectric conversion portion 14 enhances the microstructure and improves light absorption of the pixel's photoelectric conversion portion." Pet. at 18. Kuboi's photoelectric conversion films 13 does not "improve" the light absorption in the photoelectric conversion portion; they **are** the photoelectric conversion portion, as shown above. This leads Petitioners to take the untenable position that the claims require the **microstructure** to be enhanced, rather than that the microstructure enhances the photodiode. *Id.* ("Etching vertical holes

38 and embedding photoelectric conversion films 13 in photoelectric conversion portion 14 ***enhances the microstructure . . .***”) (emphasis added). This is contrary to the plain language of the claims which state that the microstructure enhances the photodetector.

Because Kuboi does not teach or suggest a “microstructure-enhanced photodiode (MSPD),” as required by each of the Challenged Claims, it cannot anticipate or render obvious any of the Challenged Claims.

VI. CONCLUSION

For all of these reasons, W&Wsens accordingly requests that the Board deny institution of *inter partes* review of the Challenged Claims of the '700 Patent.

Respectfully submitted,

Date: September 24, 2025

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Patent Owner's Preliminary Response
IPR2025-00996 (U.S. Patent No. 10,446,700)

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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 PRELIMINARY RESPONSE** has 2,162 words in compliance with the 14,000 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: September 24, 2025

/James Hannah/

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Attorneys for Patent Owner
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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 Petitioner as detailed below.

<i>Date of service</i>	September 24, 2025
<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.rajana@finnegan.com)
<i>Documents served</i>	PATENT OWNER'S PRELIMINARY 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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