

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

**DECLARATION OF DR. BRIAN D'ANDRADE
IN SUPPORT OF PATENT OWNER'S RESPONSE**

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I. INTRODUCTION

1. I, Brian D'Andrade, Ph.D., have been retained as an expert witness by W&Wsens Devices, Inc., the Patent Owner in this response to a post-grant review petition. I have personal knowledge of the facts stated in this Declaration and can testify competently to those facts. The petition was initiated by Samsung Electronics Co., Ltd., and its related entities concerning U.S. Patent No. 12,243,948 , which I will refer to as the '948 Patent. In my testimony, I will refer to W&Wsens Devices, Inc. as "W&Wsens" or the "Patent Owner." I will refer to Samsung and its related entities as "Samsung" or the "Petitioners."

2. I am being compensated for my work in this matter. My compensation does not depend on the outcome of this proceeding.

3. I have been asked to provide my technical opinions relating to the '948 Patent in relation to arguments raised by Samsung in its Petition.

II. EXPERIENCE AND QUALIFICATIONS

4. The details of my education, work experience, and research are summarized in my curriculum vitae ("CV") which is attached to this Report as Appendix A. I have summarized some of the relevant information which is on my CV herein.

5. I obtained a Bachelor of Science degree in Electrical Engineering from Pennsylvania State University in 1999. My undergraduate thesis was on

optoelectronic devices including pentacene and phthalocyanine electronics, sensors, and CMOS devices. I subsequently earned a Master of Arts and a Ph.D. in Electrical Engineering from Princeton University, completing my doctoral studies in 2004. My graduate and doctoral research focused on electrical and computer engineering, including work on organic optoelectronic devices and solid-state lighting technologies. My research also involved the fabrication and processing of semiconductor devices and the designing of optical enhancements for optoelectronic devices including microlens, gratings, antireflection coatings, and optical absorption enhancement of organic solar cells that contain nanoparticles.

6. I began my professional career in industrial research and development, including service as a Senior Scientist at Universal Display Corporation, where I worked on advanced electronic and semiconductor technologies. I later joined Exponent, Inc., an international engineering and scientific consulting firm, where I progressed through multiple senior technical roles and became a Principal Engineer.

7. I currently lead my own consulting practice, DAndrade PhD Consulting, LLC, providing expert engineering analysis in litigation and advisory matters. For example, I direct the teardown, failure analysis, or design review of various electronic products including solar modules, smartphones, sensors, and lamps.

8. I have 20 years of commercial experience in the semiconductor field including consulting on, research and development of light-emitting diodes (LEDs). I have reviewed numerous semiconductor recipes for GaN based devices, OLED, and non-volatile (Flash) memories in trade-secret and patent matters. My wide band- gap semiconductor experience includes intellectual property litigation matters on MOCVD and MBE growth methods, doping and device architectures. My non-volatile memory work experience includes shallow trench isolation, interlayer dielectrics, spacers, and other flash memory structures for either patent or trade secret litigation matters.

9. I have extensive experience serving as an expert witness in matters involving electrical, electronic, and semiconductor engineering. My expert work draws on both academic research and applied engineering practice. For example, my experience includes consulting on the manufacturing of gallium nitride blue LEDs in the matter *Lumileds LLC v. Elec-Tech International Co., Ltd et al.*, Case No. 1-15-CV-278566 in the Superior Court of the State of California, County of Santa Clara, where I provided testimony on the semiconductor processing of LEDs manufactured with MOCVD. I was an expert witness in the matter *Logitech, Inc. v. United States*, Court No. 16-00017 in the United States Court of International Trade, where I testified on camera sensors and systems including image compression and transmission.

10. I have authored numerous peer-reviewed journal articles and conference papers, particularly in the field of optoelectronics and semiconductor devices. According to Google Scholar, my publications have received many thousands of citations, reflecting the impact of my research contributions to organic light-emitting devices and related technologies. Furthermore, I edited 4 books on engineering topics and authored chapters in 7 books, including a book on nanotechnology metrology.

11. I am an inventor on over 100 patents, including several issued U.S. patents related to electronic and optoelectronic technologies, including innovations in organic light-emitting devices including innovations having optical enhancements that improve device efficiency and color quality. The New York Intellectual Property Law Association selected me as the Inventor of the Year for 2015.

12. I am a senior member of IEEE, and IEEE awarded the IEEE-SA Cloud Working Group Award to me in 2020. Senior members of IEEE represent about 8 percent of the approximately half-million members of IEEE, and they obtain that recognition by being a scientist or engineer in professional practice for at least 10 years and showing significant performance in an area over a period of at least 5 years in their profession.

13. I hold multiple professional licenses and certifications, including licensure as a Professional Engineer (P.E.) in several U.S. jurisdictions, as well as certifications in software quality, reliability engineering, information security, and electronics manufacturing.

14. I am actively engaged in the engineering profession through technical publishing, expert consulting, standards-based engineering practice, and service to academic and professional organizations, including ongoing involvement with Princeton University as an alumni interviewer and advisor.

III. MATERIALS CONSIDERED

15. My opinions, expressed herein, are based on information I have reviewed to date including the materials referenced herein and in the exhibits cited in this Declaration, and are based on my knowledge and experience in the fields of the design and manufacturing of electronics and semiconductors.

16. In the process of forming my opinions and preparing this declaration, I have reviewed and considered numerous documents and items including, but not limited to: the '948 Patent, associated file history, the petition, Petitioners' exhibits, and Patent Owner's exhibits filed in this proceeding, and the deposition testimony of Dr. Lebby filed in this proceeding.

17. Portions of my declaration, such as an overview summary of the '948 Patent, and the background of the technology, may be adapted from portions of my

expert report regarding the validity of various W&Wsens patents at issue in district court litigation between Samsung and W&Wsens.

18. All opinions set forth in my Declaration are my opinions and I am not relying on the opinions, analysis, or facts provided by counsel or other experts, except where noted (such as in the Legal Standard section of my Declaration).

IV. APPLICABLE STANDARDS AND CONTROLLING PRINCIPLES

19. Counsel for W&Wsens have informed me of the following legal standards that I have used as a framework in forming my opinions contained herein.

A. Burden of Proof

20. I have been informed that Petitioners bear the ultimate burden of proof, by a preponderance of the evidence, to demonstrate that any claim of the '948 Patent is unpatentable.

B. Anticipation

21. I have been informed that a patent claim is anticipated if each and every limitation of that claim is disclosed in a single prior art reference or single prior art product.

22. A limitation may be disclosed explicitly or inherently. A limitation is inherently disclosed in a prior art reference if an unstated limitation is necessarily present in the prior art.

23. Unless all the elements are found in a single piece of prior art in exactly the same situation and united the same way to perform the identical function, there is no anticipation. In other words, if elements are disclosed in different examples and scenarios, they would not be deemed a single anticipatory reference.

24. I have been informed that, in order for a prior art reference to anticipate a patent claim, the reference must also enable one of ordinary skill in the art to make or practice the claimed invention without undue experimentation.

25. I understand that if a patent has an effective filing date that is on or after March 16, 2013, the “post-AIA” (America Invents Act) versions of 35 U.S.C. §§ 102 and 103 apply. The '948 Patent has a priority date after this date. Therefore, I apply the post-AIA version of these statutes.

26. **§ 102(a) (Post-AIA)**. I understand that a patent is valid under 35 U.S.C. § 102(a) (post-AIA) unless the claimed invention was patented, described in a printed publication, in public use, on sale, or otherwise available to the public before the effective filing date (priority date) of the claimed invention. I further understand that prior art under post AIA § 102(a) is not limited by geographic location and may include disclosures made anywhere in the world.

27. **§ 102(b) (Post-AIA)**. I understand that, under post-AIA 35 U.S.C. § 102(b), certain disclosures that would otherwise qualify as prior art under § 102(a)

are excluded from consideration as prior art. In particular, I understand that a disclosure made one year or less before the effective filing date (priority date) of the claimed invention is not prior art under § 102(a)(1) if the disclosure was made by the inventor or a joint inventor.

C. Obviousness

28. I have been informed that if a single reference does not contain every limitation of a patent claim, it can only invalidate that claim if it would be obvious when considered in light of other prior art references or devices without viewing the combination with hindsight bias. Only if the differences between the claimed invention and the prior art are such that the claimed invention, as a whole, would have been obvious to a person having ordinary skill in the art at the time the invention was made without the benefit of hindsight is the claim is invalid.

29. I have been informed that the types of 35 U.S.C. § 102 prior art described above can individually be a basis for invalidating a patent, or these references can be combined to show a patent is invalid as obvious under 35 U.S.C. § 103. I have been informed that the analysis of obviousness involves several factual inquiries including the scope and content of the prior art, the differences between the prior art and the claim, and the level of ordinary skill in the art at the time of the invention.

30. I have been informed that the test for analogous art is very specific. I have been informed that art is non-analogous unless it is: (1) from the same field of endeavor as the claimed invention; or (2) reasonably pertinent to the particular problem faced by the inventor. I have been informed that an art citation that is not from the same field of endeavor as a claimed invention must be “reasonably pertinent” to the problem addressed by the inventor. I have been informed that art is “reasonably pertinent” when it would “logically commend itself” to an inventor’s attention in considering his problem. Conversely, I have been informed that when art is directed to a different purpose than a claimed invention, an inventor would have less motivation or occasion to consider it.

31. I have been informed that the fact that prior art references all concern the same field of endeavor is not in itself sufficient rationale for making the combination. Many types of techniques and systems exist in the same field of endeavor. That fact alone would not make it obvious to combine their features. I have been informed that a proper obviousness determination must show why a person of ordinary skill in the art would have thought to combine particular available elements of knowledge, as evidenced by the prior art, to reach the claimed invention.

32. I have been informed that a party seeking to invalidate a patent on obviousness grounds must demonstrate by clear and convincing evidence that a

skilled artisan would have been motivated to combine the teachings of the prior art references to achieve the claimed invention, and that the skilled artisan would have had a reasonable expectation of success in doing so.

33. I have been informed that the party seeking to invalidate a patent on obviousness bears the burden of particularly explaining (1) the primary and secondary references, (2) the missing elements supplied by the secondary references, (3) why a POSITA would have looked to the secondary reference to fill gaps in the primary reference, and (4) why adding the secondary reference's teaching would yield predictable results.

34. I have been informed that to establish prima facie obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art.

35. I have been informed that if the proposed modification or combination of the prior art would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims prima facie obvious.

36. I have been informed that to determine whether a combination of known elements would have been obvious to a person of ordinary skill in the art at the time of the invention, one must consider the references in their entirety to

ascertain whether the disclosures in those references render the combination obvious to such a person.

37. I have been informed that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. Additionally, I understand that a patent is likely to be invalid for obviousness if a person of ordinary skill in the art can implement a predictable variation or if there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent's claims. A combination is not obvious, however, where the combination cannot be implemented without undue experimentation or when the motivation to create the combination comes from hindsight.

38. I have been informed that, even when all claim limitations can be found in a combination of prior art references, the fact-finder must consider as part of the obviousness determination not only what the prior art teaches, but whether the prior art teaches away from the claimed invention and whether there is a motivation to combine teachings from separate references in the manner claimed.

39. I have been informed that, in assessing whether a claimed invention is obvious, secondary considerations that may weigh towards the non-obviousness of the invention, including the following, should be considered:

- Whether the claimed invention satisfied a long-felt need;

- Whether the claimed invention was preceded by a history of failures by others to solve a problem or problems solved by such invention;
- Whether the claimed invention achieved a surprising or unexpected result;
- Whether the claimed invention exhibited performance superior to prior art devices and/or methods;
- Whether the claimed invention has achieved commercial success;
- Evidence of industry acquiescence;
- Licenses;
- Whether the claimed invention has been copied;
- Whether the claimed invention was the subject of skepticism by the industry; and
- Whether the prior art taught away from the claimed invention.

40. I have been informed that there must be a nexus tying the evidence of secondary considerations to the unique characteristics of the claimed invention.

Nexus can be established via a presumption when the evidence is tied to a product that embodies and is coextensive with the claims. Even without a presumption, nexus can be shown by tying the evidence to the unique characteristics of the claimed invention. I have also been informed that nexus is not limited to only novel features but considers the invention as a whole.

D. Enablement

41. I have been informed that a patent claim meets the enablement requirement of 35 U.S.C. § 112 if the specification enables one of skill in the art to practice the claimed invention without undue experimentation. The determination of what constitutes undue experimentation in a given case requires the application of a standard of reasonableness, taking into account the nature of the invention and the state of the art. The test is not merely quantitative, since a considerable amount of experimentation is permissible, if it is merely routine, or if the specification in question provides a reasonable amount of guidance with respect to the direction in which the experimentation should proceed.

42. I have been informed that factors that are to be considered in determining whether a disclosure would require undue experimentation 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.

V. PERSON OF ORDINARY SKILL IN THE ART

43. I understand that the factors to be considered in determining the level of ordinary skill in the art to be: (1) the educational level of active workers in the

field, including the named inventors of the patent; (2) the type of problems encountered in the art; (3) prior art solutions to those problems; (4) the rapidity with which innovations are made; and (5) the sophistication of the technology in the art.

44. Based on my review of the '948 Patent and my consideration of the abovementioned factors, it is my opinion that a person of ordinary skill in the art at the time of the invention of the '948 Patent ("POSITA") would be someone with 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. A POSITA would be familiar with the interaction between photons and electrons in semiconductors and their applications.

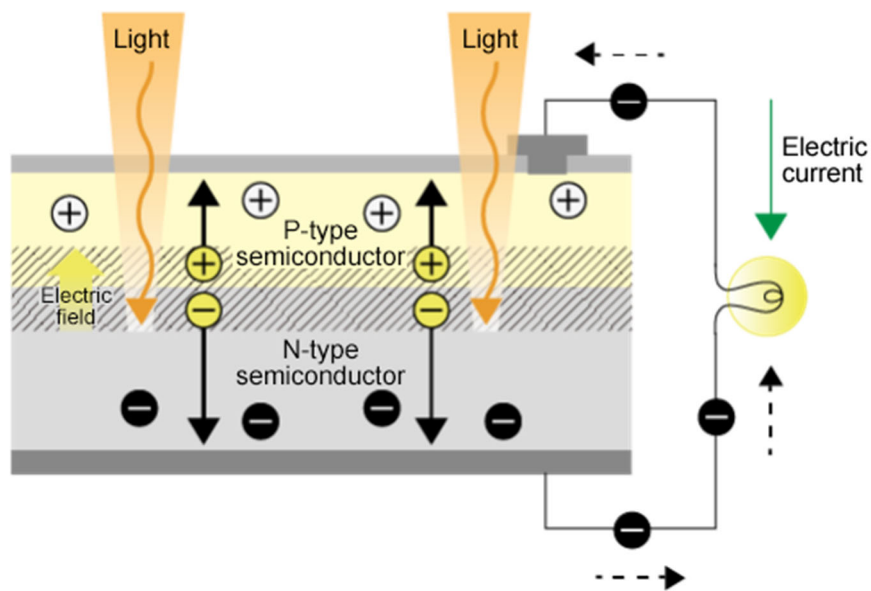
45. I was informed by counsel that W&Wsens asserts the date of invention of each of the Challenged Claims is around April 2013. My opinion as to the definition of a POSITA would not change if the Challenged Claims were found to have a different priority date.

46. In April 2013, my qualifications exceeded those of a POSITA.

VI. TECHNOLOGY OVERVIEW

A. Photodetectors Convert Light into Electrical Signals

47. Photodetectors are devices that convert incident optical radiation into electrical signals through the absorption of photons and the consequent generation of mobile charge carriers (electron-hole pairs). Ex. 2020 at 2. In my experience, a photodetector typically incorporates one or more photodiodes, which are light-sensitive semiconductor junctions that produce electrical current in proportion to the absorbed photon flux.



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

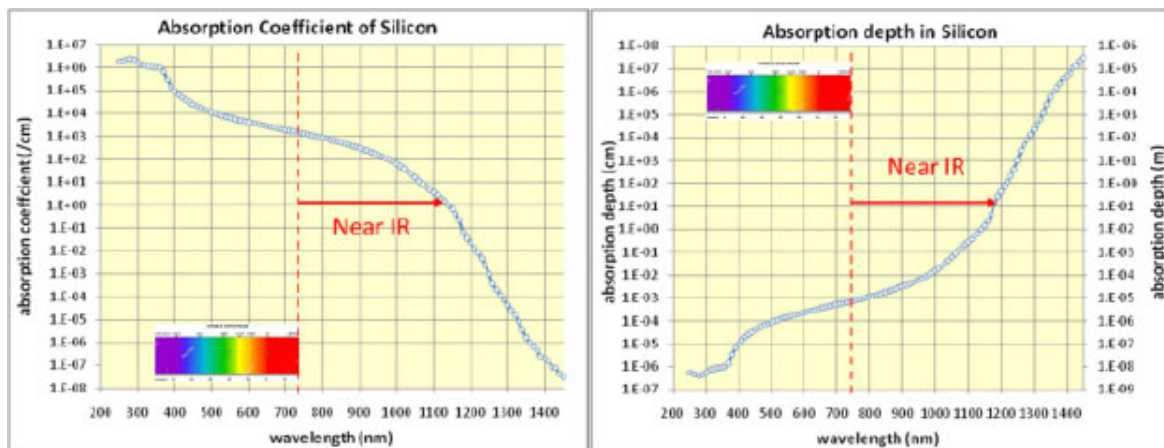
48. A photodetector can be characterized by its quantum efficiency, which is the ratio of charge carriers generated and successfully collected to the number of incident photons impinging on the device. See Ex. 1028 at 25 (“[Q] quantum efficiency η is defined as the number of photogenerated electron-hole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

contribute to the photocurrent, divided by the number of the incident photons.”) In my opinion, quantum efficiency is an important performance parameter for a photodetector because it determines how effective the conversion of incident optical power into an electrical signal is. A device with high quantum efficiency yields superior signal strength and signal-to-noise ratio, which is particularly important in low-light conditions where photon flux is limited, and device performance is often constrained by noise.

49. 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

50. Digital cameras often rely on silicon-based photodetectors because of advantages such as low material cost, well-established fabrication infrastructure, and compatibility with CMOS manufacturing processes. One downside of using silicon, however, is that its optical absorption coefficient is strongly wavelength-dependent, decreasing substantially as the wavelength of incident light extends into the red and near-infrared portions of the electromagnetic spectrum:



Ex. 2023 at 2-3 (annotations added) (illustrating silicon's decreasing ability to absorb longer wavelength light). This behavior is a direct consequence of silicon's indirect bandgap structure (it requires phonon assistance for photon absorption at longer wavelengths). As a result, silicon is relatively transparent to red and infrared radiation, and long-wavelength photons are not absorbed efficiently. *Id.*; '948 Patent at 2:4-7. In my opinion, this physical limitation is the root cause of the difficulties that traditional silicon-based photodetectors experienced in achieving acceptable

quantum efficiency and image quality under challenging conditions, particularly in dim light or when detecting near-infrared signals. '948 Patent at 1:61-2:31.

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

51. One conventional approach to overcoming silicon's poor absorption at longer wavelengths was to increase the thickness of the silicon absorption region. '948 Patent at 2:7-16. A thicker photodetector provides a longer optical path length through the (thicker) silicon, thereby increasing the probability of photon absorption. Based on my understanding of silicon's absorption properties, for wavelengths longer than approximately 730 nm, the photoconverting region of silicon (Si) would need to be at least 10 μm thick merely to absorb 64% of the incident light. Ex. 2023 at 2-3.

52. In my opinion, 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. '948 Patent at 2:7-18. Thicker devices are also less compatible with densely packed pixel architectures of the type used in modern smartphone cameras.

53. 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 sufficient light absorption and maintain acceptable image quality.

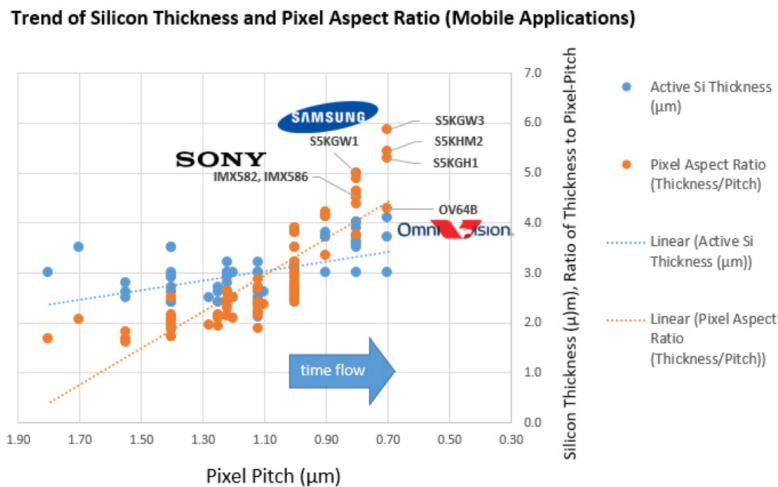


Figure 3 Trend of silicon thickness to pixel pitch ratio.

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

54. However, the simultaneous pursuit of thicker silicon and smaller pixel dimensions created difficulties, particularly significant manufacturing challenges, such as 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 near-infrared spectral range. Although there are semiconductor materials with better absorption

properties than silicon, including direct-bandgap materials like indium gallium arsenide (InGaAs), these materials are substantially more expensive and can exhibit higher multiplication noise when compared with silicon. '948 Patent at 2:19-31. In my opinion, for many applications, like high-volume consumer application, silicon-based photodetectors remain effectively the only viable 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.").

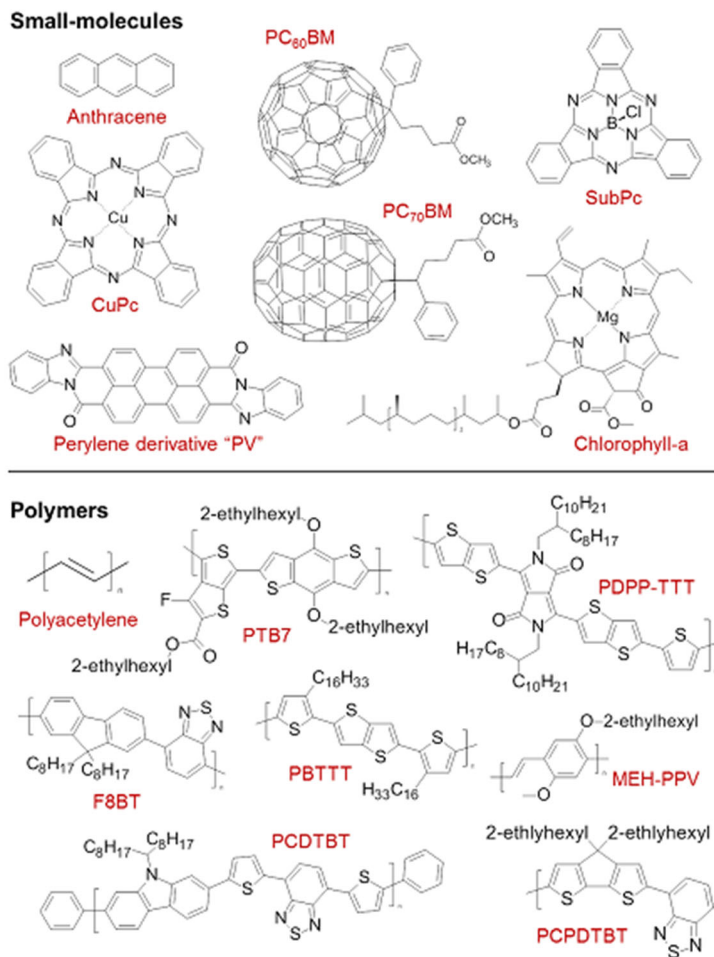
55. In my opinion, these combined limitations created a well-recognized need in the industry to improve the quantum efficiency of silicon photodetectors—specifically, to enable smaller and thinner pixel architectures that could nonetheless capture sufficient photons to generate high-quality images. '948 Patent at 1:61-2:31, 8:17-35.

D. Organic Semiconductors are Different From Inorganic Semiconductors

56. Organic semiconductors have many fundamental differences as compared to inorganic semiconductors, such as silicon.

57. There are many kinds of organic semiconductors as the examples show below. The carbon bonds create periodic atomic arrangement in relatively short range (in <20nm range) as compared to their inorganic counterparts (in >1000nm range). Because of short ranges, the conduction mechanisms between

organic molecules are very different from those in the lattice forming the inorganic semiconductors.



Ex. 2049 at 3 (Figure 3) (showing Chemical structures for a range of commonly used small-molecule and polymer semiconductors. CuPc = Copper phthalocyanine, SubPc = boron subphthalocyanine chloride).

58. As noted above, organic compounds containing conjugate bonds such as $-C=C-C=$. Ex. 2050 at 4. These molecules have limited lengths. The periodic structures created by molecules with limited length generate discrete energy states.

For inorganic semiconductors, the periodic structures cover thousands or millions of atoms. Therefore, in practice, inorganic semiconductor structures create continuous energy states. Such continuous energy states allow electrons to move freely in the crystals. The same is not true for organic semiconductors, the electrons move between different molecules by band transport, hopping, and polaronic transport. Ex. 2051 at 213. This is the fundamental reason that organic semiconductors are not very conductive.

59. The most widely used optical devices made of organic semiconductors is Organic Light Emitting Diodes (OLED). They are used to make displays for Television or smartphones. There are some reports on organic solar cells. There are less significant discussions in the literature, especially at the time of the invention, reporting on organic photodetectors. *See, e.g.*, U.S. Patent Nos. 9,666,817 (organic photodetector) (Ex. 2052), 9,673,258 (organic photodiodes) (Ex. 2053).

60. Integrating organic semiconductors with CMOS technology faces several significant technical hurdles including at least thermal instability of the organic materials, speed of the hybrid device, noise, environmental degradation, and interface issues.

61. Standard CMOS fabrication involves several steps that require temperatures exceeding 200°C to 400°C (e.g., for annealing or dielectric

deposition), but most organic molecules and polymers degrade, melt, or undergo unfavorable phase changes below those temperatures. Hence, this organic semiconductor limitation requires the use of low-temperature processing, which can compromise the quality of the CMOS metal interconnects or require the organic layer to be deposited at the very end of the manufacturing chain, limiting design flexibility.

62. Organic semiconductors have much lower charge-carrier mobility compared to crystalline silicon due to the fundamentally different physics of conduction. In silicon, electrons move through a continuous crystal lattice, whereas charges must hop between discrete organic molecules. This slow hopping process results in slow response times and low bandwidth. While silicon photodetectors can handle gigahertz speeds, many organic photodetectors struggle to exceed the megahertz range.

63. Organic semiconductors are amorphous and can have high dark current because they are prone to defects, for example, that act as leakage paths for current. A high dark current leads to high electronic noise, which reduces the sensitivity of the sensor, making it harder to capture clear images in low-light conditions.

64. In terms of environmental stability, the exposure to oxygen and moisture causes photo-oxidation which causes the organic molecules to break

down. Tiny amounts of water vapor can cause black spots or delamination of the organic film from the CMOS substrate, for example. Hence, organic sensors require encapsulation, which adds significant thickness and cost to the final chip package.

65. For a circuit to work, electrons need to move smoothly between interfaces that may exist between the regions in the semiconductor. CMOS technology has decades of data on how to control the conductivity of the various regions; however, organic materials have specific HOMO (Highest Occupied Molecular Orbital) and LUMO (Lowest Unoccupied Molecular Orbital) levels and other energetic barriers to charge transport such as interface dipoles that do not enable organic materials to be readily integrated with CMOS. Ex. 2049 at Figures 1-2. Finding organic materials that are compatible with CMOS foundries and have the right energetics to control charge movement into and out of organics without a massive energy barrier is incredibly difficult.

66. Hence, a POSITA would not look to combine organic and inorganic semiconductor references and would not consider organic semiconductors pertinent prior art to the claims directed to inorganic semiconductors.

VII. CLAIM CONSTRUCTION

A. Claim Construction Principles

67. I have been informed through counsel that during this post-grant review proceeding (because this petition for post grant review was filed after November 13, 2018), claims terms should be given their “ordinary and customary meaning as would be understood by a person of ordinary skill in the art in question at the time of the invention.” I have further been informed that for determining the meaning of a disputed claim term, it is appropriate to “look principally to the intrinsic evidence of the record, examining the claim language itself, the written description, and the prosecution history.” I understand that a term is introduced with an indefinite “an” article and subsequently referred to with the definite “the” article. I further understand that extrinsic evidence can be helpful in demonstrating how a term is used in the art, and how the plain meaning is applied in the context of the intrinsic record.

68. I understand that the Patent Office will look to the specification and prosecution history in construing a given claim term. I understand the Patent Office will also sometimes look to other evidence, which I am informed is called “extrinsic” evidence, including dictionary definitions, for how a person of ordinary skill in the art would have understood a claim term.

69. I understand that a patent's "specification" includes all of the figures, discussion, and claims within the patent, including those that are incorporated by reference. I understand that the "prosecution history" includes the statements made to and dialogue with the patent office in the course of obtaining the patent, and that the prosecution history of any parent application can contain relevant information.

B. Claim Constructions Here and In Related Cases

70. I understand that in its Petition, Petitioners assert that "no terms need construction." Pet. at 7.

71. I understand that in parallel district court litigation, W&Wsens and Samsung have taken specific claim construction positions. *See W&Wsens Devices Inc. v. Samsung Electronics Co., Ltd. et al.*, Case No. 2:24-cv-00854-JRG (E.D. Tex.). I understand that both parties have submitted proposed claim constructions to the district court, and a claim construction order has not been issued yet.

72. I understand that the below tables contains the parties' competing proposed constructions for disputed claim terms. In my opinion, 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 (<i>e.g.</i> , not isolation trenches)

Term	W&Wsens' Proposed Construction	Petitioners' Proposed Construction
“holes that are fabricated as recesses at or under the light-receiving surface of each of at least some of the pillars . . . extend[s] into the pillar[s]”	Plain and ordinary meaning	“holes deliberately formed in a pillar of a photodetector for absorbing light that is converted to electricity”

Ex. 2046 at 1-2.

73. I also understand that 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.

VIII. OVERVIEW OF THE '948 PATENT

A. The '948 Patent

74. In my opinion, the '948 Patent discloses inventions that overcome limitations of conventional silicon CMOS sensors by using 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, Abstract and 10:13-23, 10:60-67, 11:45-51, 15:26-35.

75. In my opinion, 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 8:17-35, 9:4-14.

76. I note that W&Wsens disclosed its microstructure technology in an article in the *Nature Photonics* journal. Ex. 2010 ("Nature Photonics Article"). It is very noteworthy for a research paper to be published in the Nature journals. This typically means that the research is peer-reviewed and determined to be highly important and that it will have a major impact on the field. I reviewed the Nature Photonics Article, and it showed examples of thin-silicon high-speed photodiodes made using its microstructure holes and reported on the improvement in sensitivity that they provided.

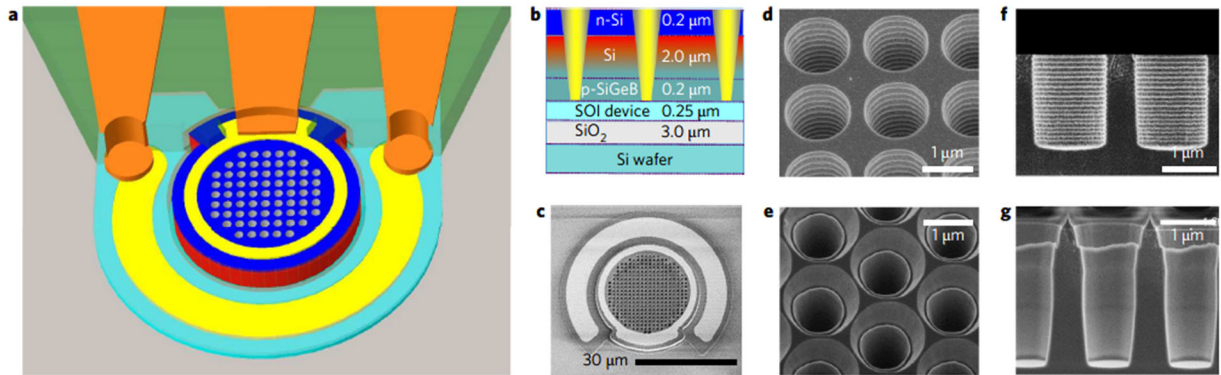


Figure 1 | Silicon photodiode with integrated micro- and nanoscale holes. **a**, Schematic of the ultrafast photodiode with a thin absorbing region. Colour coded layers: blue, n-Si layer; red, i-Si layer; turquoise, p-Si layer; transparent, insulating nitride/oxide layer; yellow, ohmic contact metal; brown, high-speed coplanar waveguide (CPW); green, polyimide planarization layer. **b**, The n-i-p photodiode structure on an SOI wafer, showing the integrated tapered holes that span the n, i and p layers. **c**, Scanning electron micrograph of the active region of a high-speed photodiode (30 μm diameter). **d,e**, Square (**d**) and hexagonal (**e**) hole lattice integrated in the photodiodes. **f,g**, Cross-sections of cylindrical (**f**) and funnel-shaped or tapered (**g**) holes etched into the active photodiode regions.

77. I note that *Nature* reports that the Nature Photonics Article has been accessed over 12,200 times and cited 243 times. Ex. 2054 at 1-2 (<https://www.nature.com/articles/nphoton.2017.37/metrics>). *Nature* further reports that according to the Altmetric, which tracks online attention an article receives, the Nature Photonics Article is ranked in the 95th percentile for “tracked articles of a similar age in all journals” and 70th percentile for “tracked articles of a similar age in Nature Photonics.” *Id.* Given the prestige and selectivity of the Nature journals, this is a significant indicator of the quality and impact of the article. In my opinion, the publication of W&Wsens’ technology in the prestigious *Nature* journal is evidence of the importance and significance of W&Wsens’ inventions.

78. Based on my review, 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:

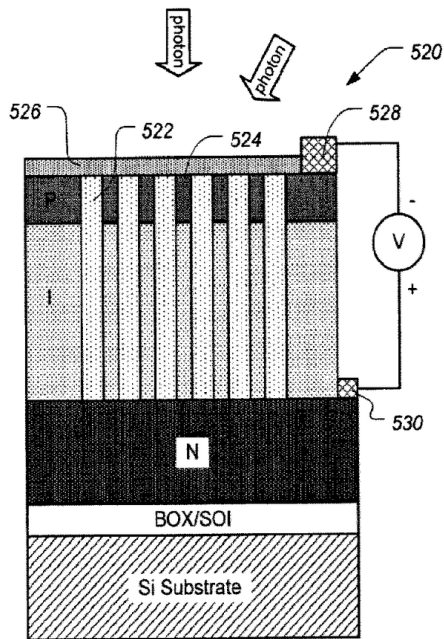


FIG. 5B

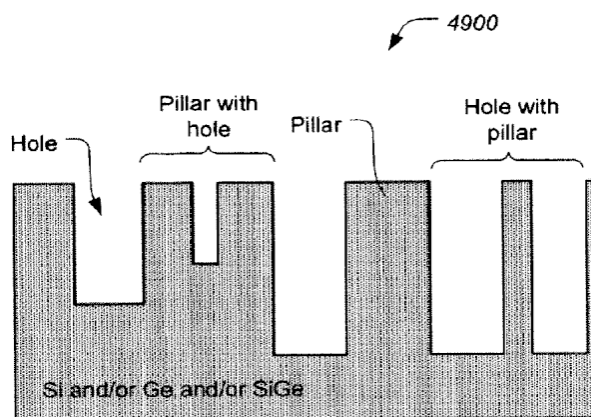


FIG. 49

'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).

79. In my opinion, this structure and arrangement of in-pillar holes results in a marked increase in light absorption compared to photodetectors lacking these in-pillar holes. The claims reflect this, reciting that "the 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." *Id.* at 55:64-67.

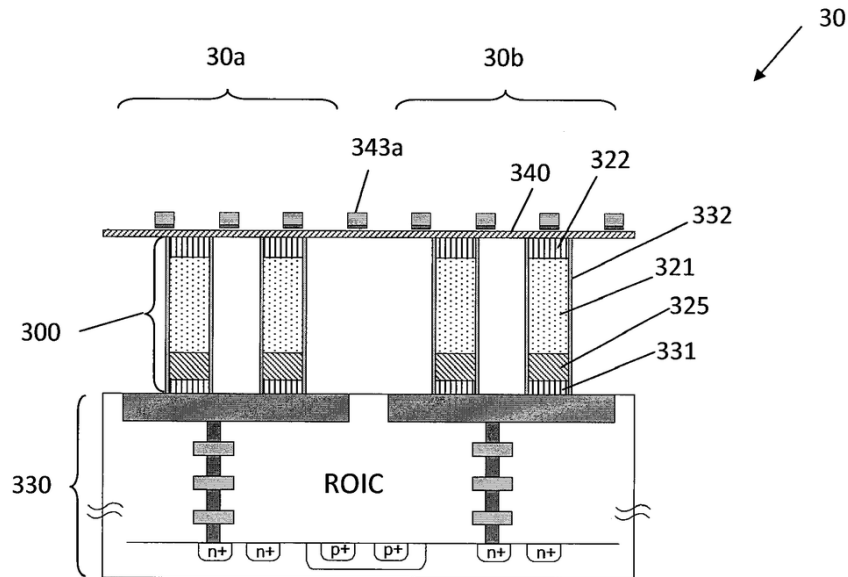
B. The Prosecution History of the '948 Patent

80. I have reviewed the prosecution history of the '948 Patent. In the Reasons for Allowance, the Examiner explained 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 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. 1003 at 22-23 (emphasis added); *see also 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.”).

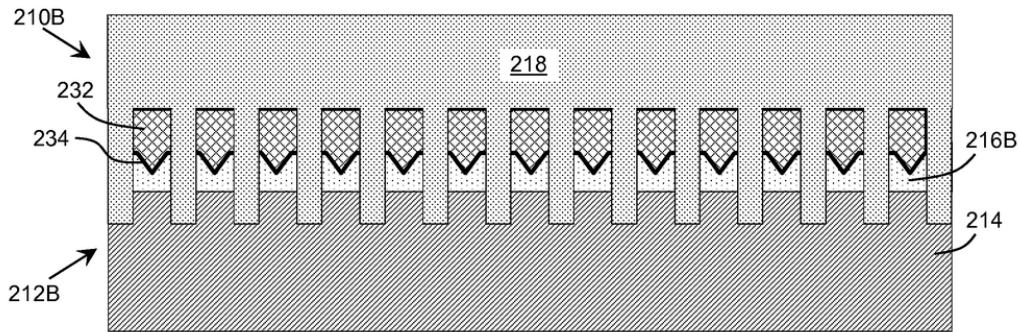
81. I note that the Examiner cited Fig. 5 of Yu-331 (Ex. 2026) (reproduced below) as disclosing “pillar shaped photodetector devices,” but found that Yu-331 fails to disclose, among other elements, the presence of the claimed in-pillar holes that increase absorption by at least 1.1x:



Ex. 1003 at 22; Ex. 2026 (Yu-331), Fig. 5.

82. I also note that the Examiner 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.

83. 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.

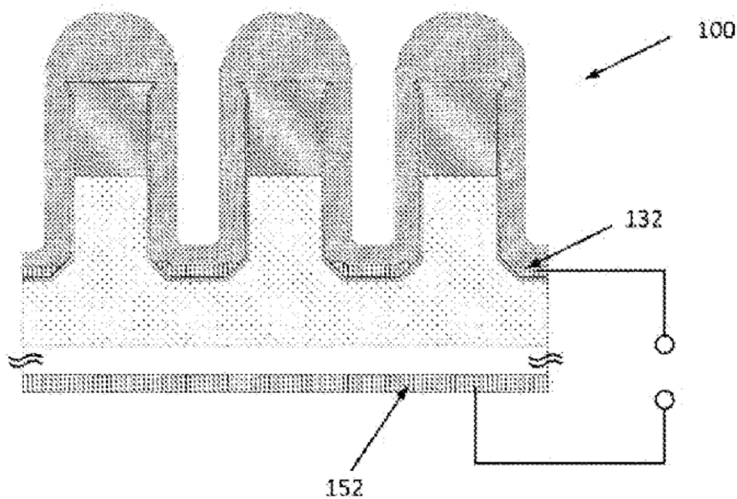
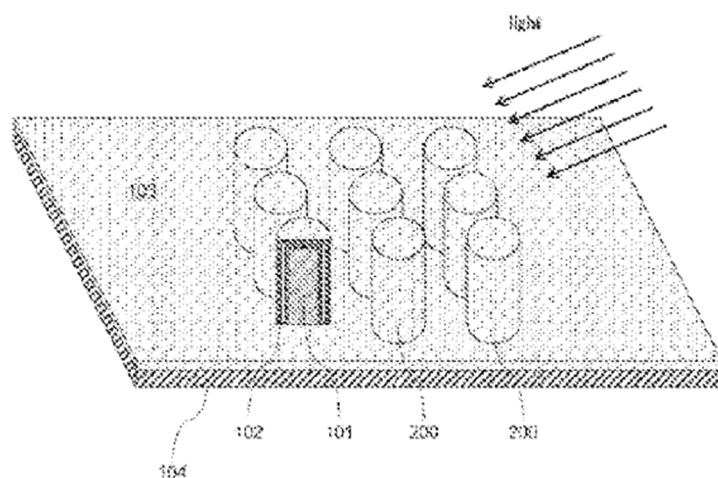


Fig. 8A

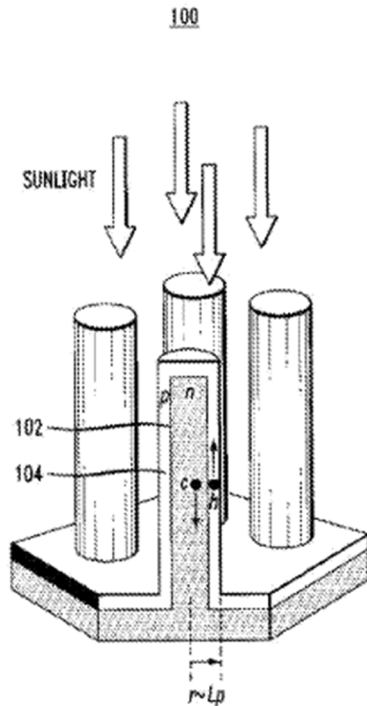
Id. at 296 (citing U.S. Pat. No. 9,515,218 to Yu, Fig. 8A).

84. In another example, I note that the Examiner cited 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).

85. Lastly, I note that the Examiner cited 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, Fig. 1).

86. Based on my review of the prosecution history, 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," and the holes enhancing light absorption by a specific amount. As I

discuss below, in my opinion, Samsung's asserted references in this PGR also lack these key features.

C. Ex-Parte Reexamination of the Related '871 Patent

87. I understand that the Patent Office recently denied Petitioners' request for *ex parte* reexamination of U.S. Patent No. 12,087,871 ("the '871 Patent"). Ex. 2040. I also understand that the Office similarly denied Petitioners' request for *ex parte* reexamination of the grandparent patent (U.S. Patent No. 11,621,360), of which the '871 Patent is a divisional. *See generally* Ex. 2041. I understand that the '871 Patent is the '948 Patent's parent, and that the '360 Patent is the '948 Patent's grandparent. I also understand that the EPR request repeated Petitioners' invalidity challenge from IPR2025-00993, using Kuboi, Shinohara, and Yu (Ex. 1025). I also understand that 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) and that reexaminations were ordered in those cases on April 20, 2026. I also understand that the Office denied institution of IPR2025-00993 challenging the '871 Patent based on a review of discretionary considerations. *See*, Case No. IPR2025-00993, Paper 14 (November 20, 2025). In my opinion, the Office's decision and findings address issues that are relevant to the prior art arguments presented in Petitioners' case.

88. I note that 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 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.

89. I have reviewed the claims of the '871 Patent, which the Office found Kuboi incapable of teaching (in the '871 EPR). '871 Patent at 55:42-67. In my opinion, the '871 Patent contains corresponding and similar limitations to the '948 Patent. Below is a comparison of relevant claim limitations between the '948 Patent and '871 Patent.

'948 Patent Claim 1 Limitation	'871 Patent Claim 1 Limitation
[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	“wherein at least some of the pillars are configured as photodetectors that have respective light-receiving surfaces and have sides”

light-receiving surfaces and respective sides;”	
[1b]: “wherein at least some of the pillars ... are configured to respond to illumination with light in selected visible and infrared wavelengths by generating electrical charge carriers;”	“wherein at least some of the photodetectors ... are configured to 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.”

90. I understand that 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. I understand that 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 at 2. I have reviewed Dr. Lebby’s EPR declaration, in which he 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 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 my opinion, Dr. Lebby presented to the Office the very prior-art mapping that he now uses in this proceeding. And it is my understanding and that the Office rejected it.

91. I have reviewed the Office’s findings, which I consider to be directly relevant to the issues in this proceeding. 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 at 7. The Office then found that “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.

92. 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 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.” Ex. 2040 at 7 (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. Ex. 2040 at 7. In my opinion, these conclusions are consistent with my own technical analysis of Kuboi, as I discuss further below.

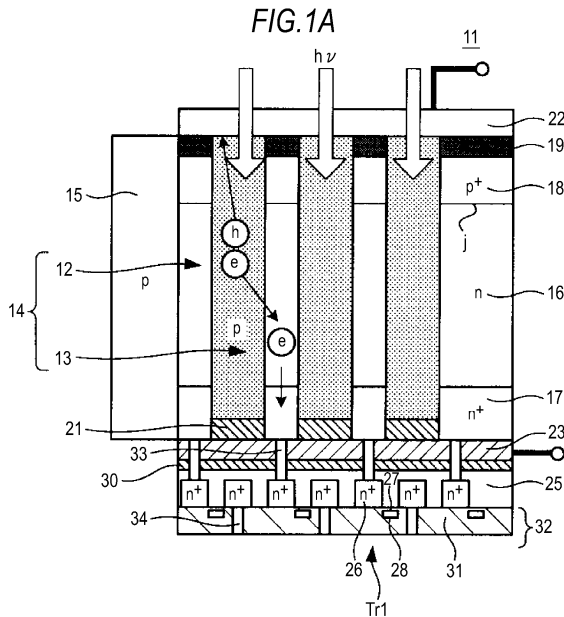
93. In my opinion, the Office’s findings in the reexamination decisions for the parent '871 Patent and grandparent '360 Patent are consistent with the patentability of the Challenged Claims of the '948 Patent, and they confirm that the prior-art mapping underlying Petitioners' invalidity theory has already been considered and rejected by the Patent Office on the merits.

IX. ASSERTED REFERENCES

A. Kuboi (Ex. 1004)

94. I have reviewed Kuboi (U.S. Patent Application Publication No. 2012/0049044 A1), published March 1, 2012, which is titled “Solid-State Imaging Device, Manufacturing Method Thereof, and Electronic Apparatus.” Based on my review, Kuboi discloses a back-illuminated solid-state imaging device in which each pixel includes a hybrid photoelectric conversion portion that combines a semiconductor layer having a p-n junction with a plurality of columnar or cylindrical organic material layers disposed within that semiconductor layer, together with a pair of electrodes positioned above and below the structure. Kuboi at Abstract, [0011]-[0012].

95. Based on my technical review, it is my opinion that 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].



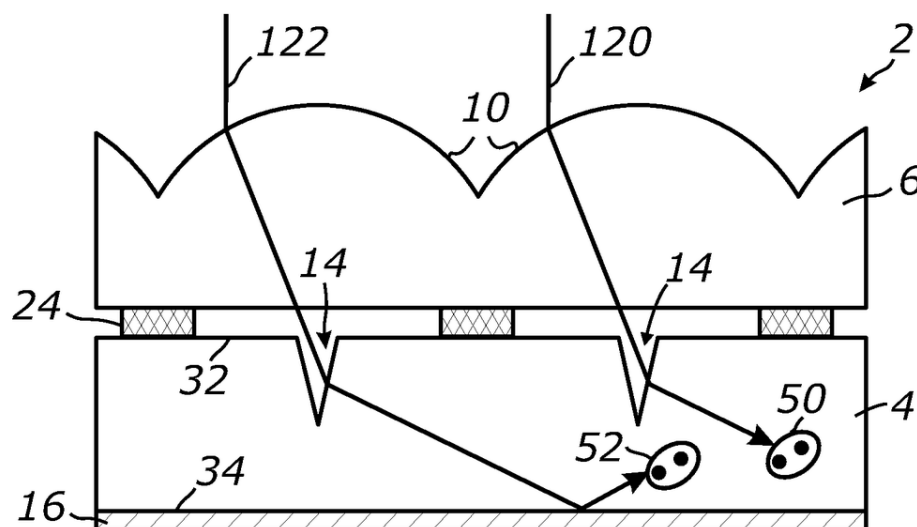
Id., Fig. 1A (showing Kuboi’s hybrid structure).

96. In my opinion, Kuboi’s imaging device is fundamentally different from the photon-absorbing, silicon/germanium-based image sensors claimed in the ’948 Patent. Kuboi’s 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, based on my technical analysis and as I describe in greater detail below, it is my opinion that Kuboi does not disclose a microstructure-enhanced photodetector device that absorbs light in pillars of Si, Ge, or a SiGe alloy, because Kuboi 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.

B. Vasylyev (Ex. 1005)

97. I have reviewed Vasylyev (U.S. Patent Application Publication No. 2012/0012741 A1), published January 19, 2012, which is titled “Light Harvesting System Employing Microstructures for Efficient Light Trapping.” Based on my review, Vasylyev discloses a light harvesting system employing a focusing array and a photoresponsive layer in which a plurality of microstructured areas is formed. Vasylyev at Abstract.

98. In my opinion, 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”). Based on my review, 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].



Id., Fig. 11 (showing light input ports 14).

99. I note that W&Wsens disclosed Vasylyev to the Office during examination of the '948 Patent, and the Office expressly allowed the claims of the '948 Patent over Vasylyev. Ex. 1003 at 487 (IDS filed 9/3/2024), 319 (IDS considered). I understand that in Grounds 2 and 4, Samsung relies 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).

C. Shinohara (Ex. 1006)

100. I have reviewed Shinohara (U.S. Patent Application Publication No. 2012/0033119 A1), published February 9, 2012, which is titled “Solid-State Imaging Device, Manufacturing Method Thereof, and Electronic Apparatus.” Ex. 1006 at 1. Based on my review, Shinohara discloses a solid-state imaging device having a backside illuminated structure that includes a pixel region in which pixels (each having a photoelectric conversion portion and a plurality of pixel transistors) are arranged in a two-dimensional matrix, and an element isolation region that

isolates the pixels and includes a semiconductor layer provided in a trench by epitaxial growth. The device further includes a light receiving surface located at the rear surface side of a semiconductor substrate, opposite to a multilayer wiring layer. Shinohara, Abstract.

101. Based on my review, I note that Samsung does not contend that Shinohara (Ex. 1006) teaches any of the microstructure claim limitations of the Challenged Claims that are absent 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. I understand that Samsung cites 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).

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

102. Based on my technical review of the asserted prior art, it is my opinion that Kuboi, Vasylyev, and/or Shinohara do not teach or suggest at least the following limitations of the Challenged Claims:

- (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”).

103. Each independent Challenged Claim recites each of these limitations.

In my opinion, the failure of the asserted prior art to disclose any one of these limitations provides an independent basis to uphold the patentability of the '948 Patent.

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

104. Based on my technical review, it is my opinion that 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 illustrated in FIG. 49 of the '948 Patent, pillars are structural features with light receiving surfaces and sides:

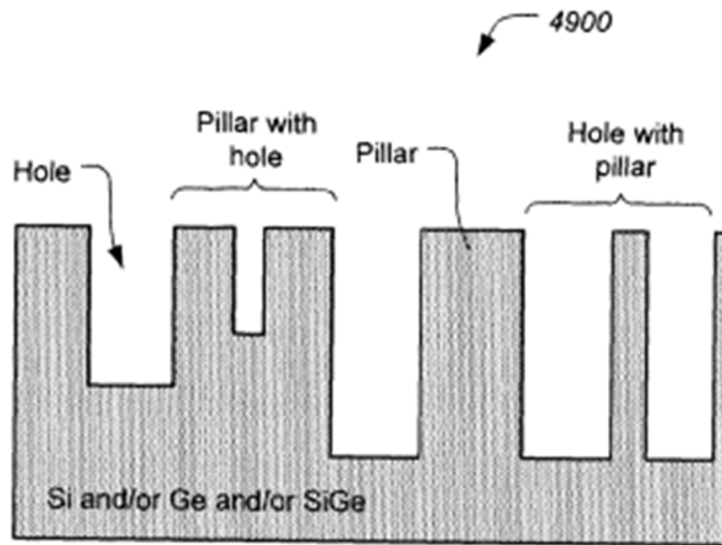
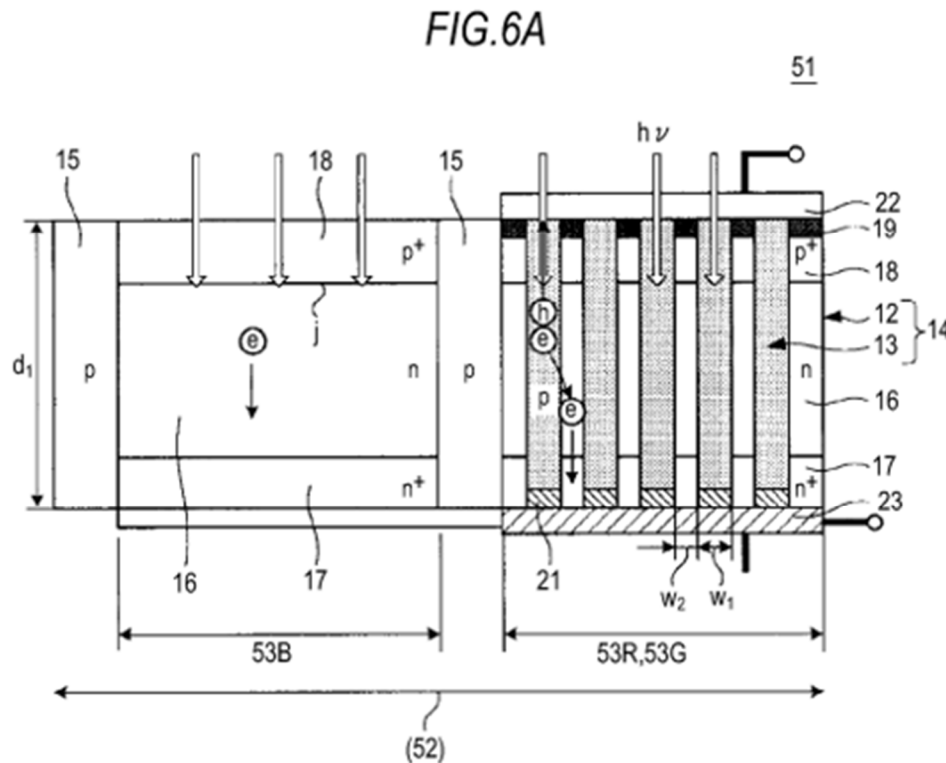


FIG. 49

'948 Patent, FIG. 49.

105. In my opinion, 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. Based on my review, 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. In my opinion, there are no pillars as recited in the Challenged Claims, with respective light-receiving surfaces and “sides.”

106. Therefore, it is my opinion that 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.

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

107. Based on my technical review, it is my opinion that 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).

108. In my opinion, 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. *Id.* at 3:6-35 (describing “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 P-I-N . . . junction area)”).

109. Based on my review, 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. Kuboi discloses that a “light

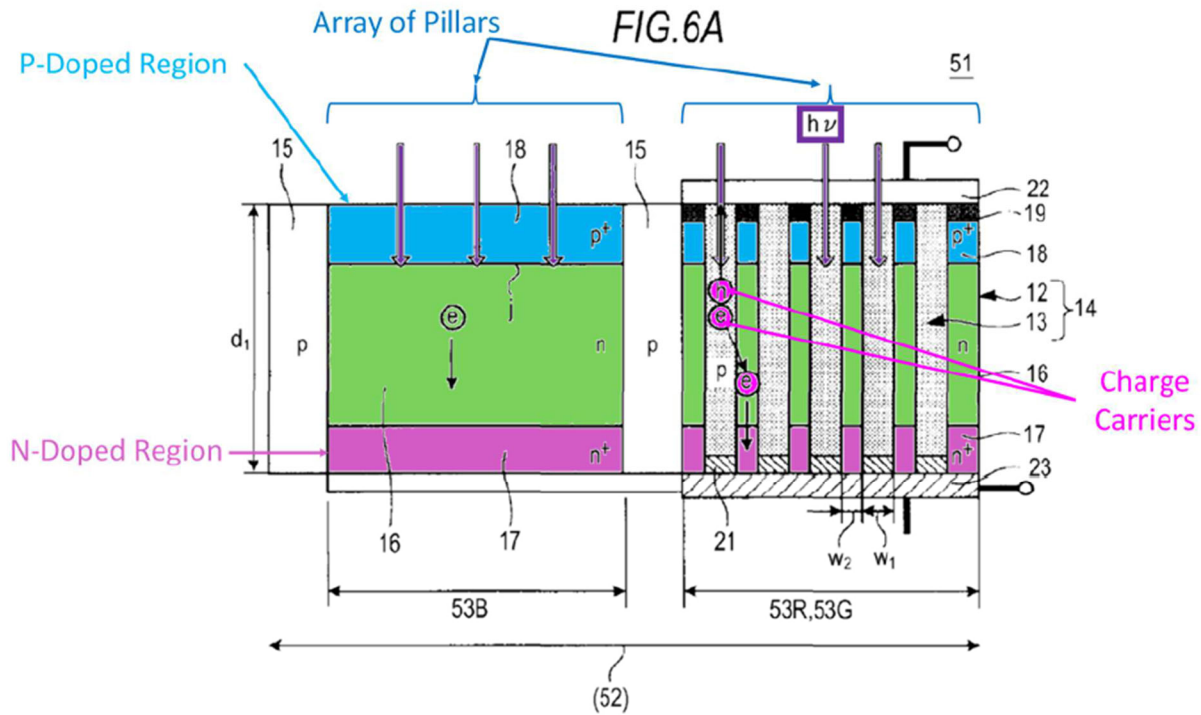
shielding film 19” ensures “that light hv does not enter the semiconductor layer 12.” Kuboi at [0059] (emphasis added), [0064] (“The light hv does not enter the semiconductor layer 12 due to the light shielding film 19.”).

110. I note that 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 103:2-5. In my opinion, this admission is technically significant. The purpose of light-shielding film 19 in Kuboi is not incidental; it is a structural element that is deliberately introduced so that incident photons are directed into the organic photoelectric conversion film 13, rather than into semiconductor layer 12, which merely acts as a carrier transport medium. As Kuboi itself expressly states at multiple points: “[p]hotoelectric conversion is performed in the organic material layer of the hybrid photoelectric conversion portion, and charges generated in the organic material layer move inside the semiconductor layer toward the charge accumulation region.” Kuboi at [0014]; *see also id.* at [0011], [0012], [0064]. In my opinion, a device in which the silicon layer is intentionally shielded from incident photons cannot be said to disclose pillars of Si, Ge, or SiGe material that 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. ’948 Patent at 55:39-47. This is precisely the opposite design

philosophy from the '948 Patent, in which microstructure-enhanced Si/Ge/SiGe pillars are specifically configured to absorb incident light and generate charge carriers within the inorganic semiconductor material itself — not to transfer that function to an organic photoelectric conversion layer embedded within openings of the silicon.

111. In my opinion, rather than using 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].

112. Based on my review, 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:



113. I note that, with respect to the ex parte reexamination 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]).

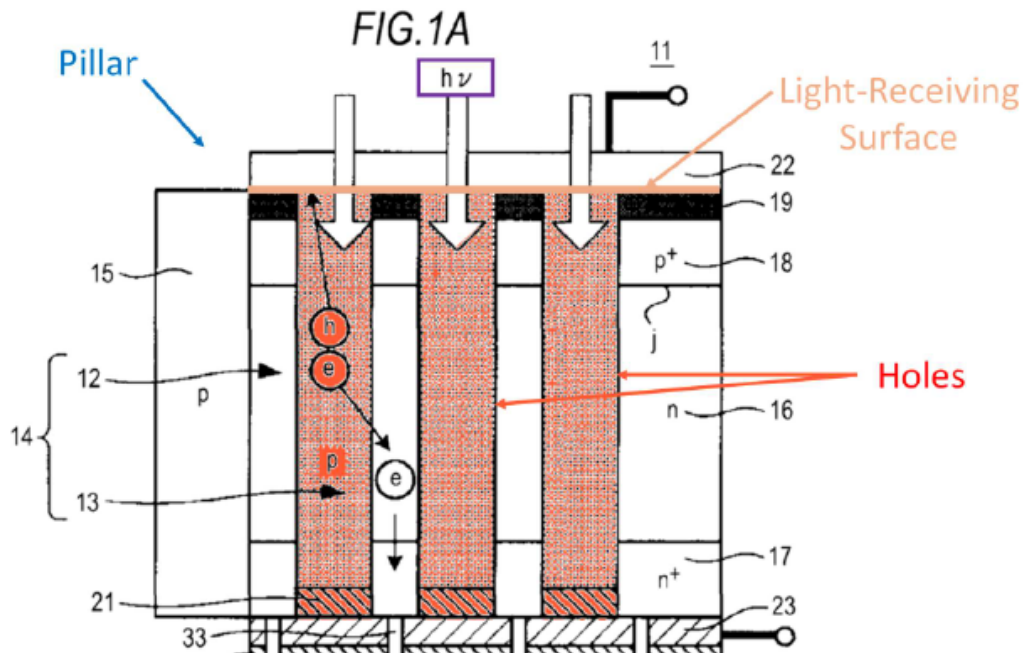
Ex. 2040 at 7 (emphasis added). In my opinion, the Office's findings are consistent with the conclusion of my own technical analysis, and I understand that Petitioners have not explained why the Office, faced with the same prior art references and arguments, should reach a different result here.

114. For these reasons, it is my opinion that 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.

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

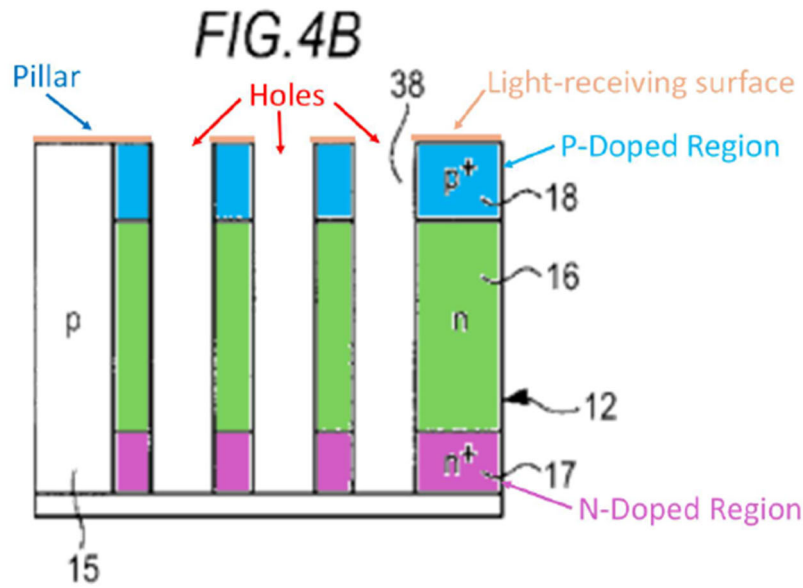
115. Based on my technical review, it is my opinion that Kuboi fails to teach or suggest “one or more holes that are fabricated as recesses at or under the light-receiving surface of each of at least some of the pillars,” as recited by the Challenged Claims.

116. I understand that Samsung maps 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”); *see also* Pet. at 26-30 (discussing limitation [1c]). *See* Lebby Tr. at 84:13-85:10 (confirming this position).



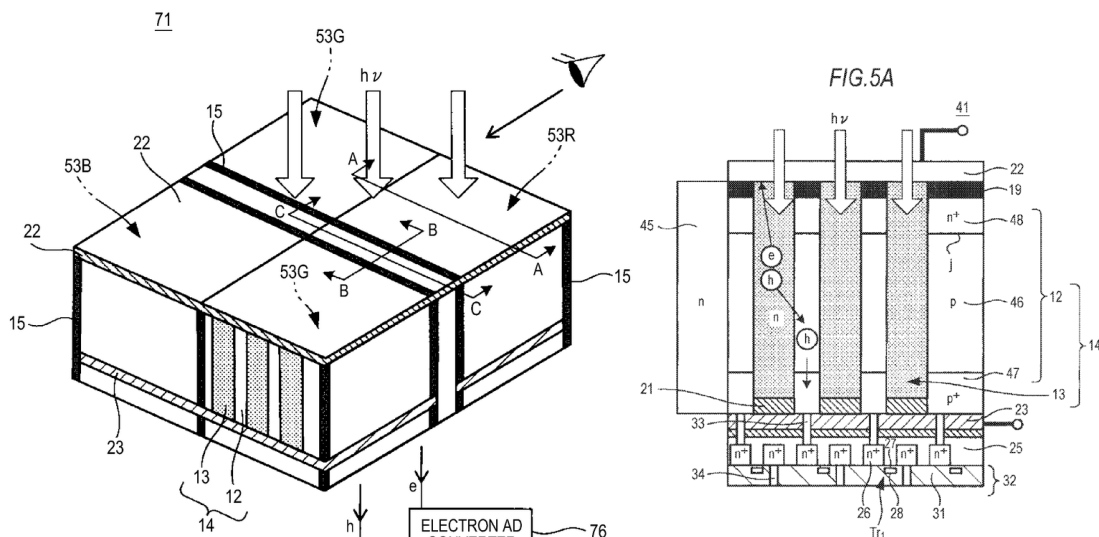
Id. at 28 (citing Kuboi, Fig. 1A, annotated). In my opinion, this mapping fails for two reasons:

117. **First**, based on my review of Kuboi, the alleged 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:



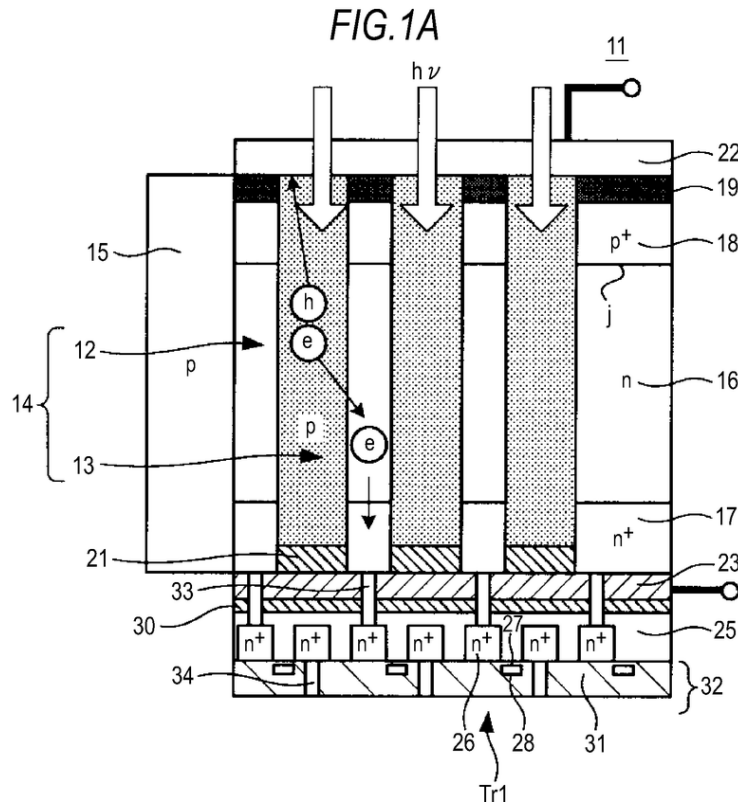
Pet. at 27 (citing Kuboi, Fig. 4B (annotated)); see Kuboi at [0072] (disclosing openings dry-etched into region 18).

118. Based on my review, there are no holes fabricated as recesses at any surface of the upper electrode 22. Kuboi's Figs. 13 and 5A (reproduced below) show a solid, continuous electrode 22 with no holes, recesses, openings, or etched features in its top surface, bottom surface, or interior.



Kuboi, Figs. 13 (excerpted) and 5A. I note that Petitioners' expert Dr. Lebby confirmed during his deposition that the upper electrode 22 "does not have holes etched in it." Lebby Tr. at 104:21-105:8. Based on my review of Kuboi's fabrication process, the dry-etching steps described in Kuboi at paragraphs [0069]-[0077] are performed in the p-type region 18 of semiconductor layer 12 and no subsequent etching step in Kuboi creates recesses in or through upper electrode 22.

119. ***Second***, in my opinion, the top of p-type region 18 (where the holes are actually etched) is not a light-receiving surface. Based on my review, 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 [0087] ("The light $h\nu$ does not enter the semiconductor layer 12 due to the light shielding film 19.").



Kuboi, Fig. 1A (showing light $h\nu$ entering holes 38 and not the semiconductor layer due to the light shielding film 19). In my opinion, 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.

120. In my opinion, Samsung's mapping of the claimed "holes that are fabricated as recesses at or under the light-receiving surface" to Kuboi's structures fails because neither the upper electrode 22 (Samsung's proposed "light-receiving surface") nor the p-type region 18 (where holes 38 are actually etched) contains

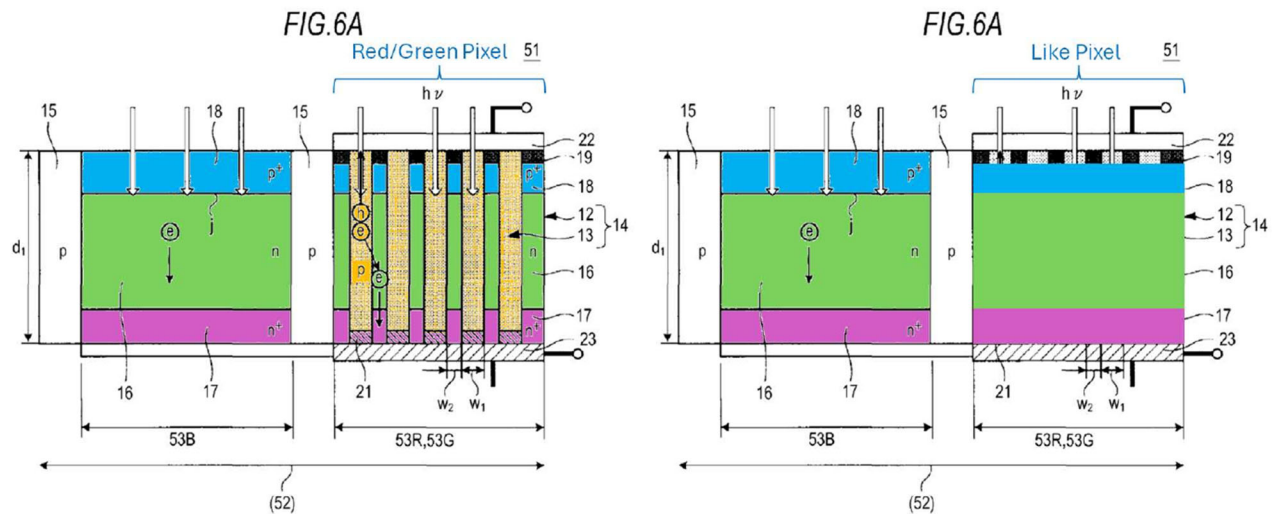
recesses that qualify as claimed "holes" within the meaning of the Challenged Claims. Accordingly, it is my opinion that Kuboi does not disclose “one or more holes that are fabricated as recesses at or under the light-receiving surface of each of at least some of the pillars,” as required by the Challenged Claims.

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

121. Based on my technical review, it is my opinion that 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. In my opinion, none of the asserted references disclose the “hole” microstructures or an improvement to the light absorption properties of photodetectors because of the “hole” microstructures.

122. I understand that Samsung does 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, I understand that Samsung relies on 24 pages of expert testimony purporting to estimate an improvement in light absorption from the references’ proposed designs. *Id.* at 40-52 (citing Lebby Decl., ¶¶ 175-201). I disagree with Dr. Lebby, for the reasons I discuss below.

123. I have reviewed Dr. Lebby's attempt 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. Lebby Decl. ¶¶ 175-187. To do so, Dr. Lebby purports to compare the photodetectors to alleged "like photodetectors lacking said holes":



Lebby Decl., ¶ 180 (citing Kuboi, Fig. 6A (annotated) (left image with 53R/53G pixel with organic material in the in-pillar holes) and Kuboi, Fig. 6A (annotated) (right image with *like* pixel without holes)).

124. I understand that 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. I understand that Dr. Lebby’s alternative analysis regarding “Hypothetical pixel without in-pillar holes and no light shield” is therefore not relevant to the Challenged Claims’ validity. Lebby Decl., at ¶¶ 181, 183-187.

125. In my opinion, 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. The fundamental problem with Dr. Lebby's analysis is that in Kuboi's red/green pixel design, the openings (holes 38) are not passive microstructures that enhance absorption in an underlying silicon photodetector — they are the locations of organic photoelectric conversion film 13, which is the active element that absorbs light and generates electron-hole pairs. Kuboi states expressly that “[t]he organic material layer 13 is the region where photoelectric conversion is performed,” and that “[l]ight $h\nu$ passes through the on-chip microlens to enter the p-type organic photoelectric conversion film 13, in which the light is subjected to photoelectric conversion, whereby electron-hole pairs are generated.” Kuboi at [0057], [0064]. Accordingly, a “like photodetector” that lacks holes in the sense Dr. Lebby describes (one where the openings are filled with silicon rather than organic material) would be a device that has no organic photoelectric conversion film at all, and, since Kuboi's silicon layer is deliberately shielded from light by light-shielding film 19, would also have no photon absorption pathway. Such a device would not function as a photodetector for red or green wavelengths, because neither the silicon nor any other element of the

structure would be configured to absorb those wavelengths and generate charge carriers under Kuboi's design.

126. By contrast, the '948 Patent's "like photodetector lacking said holes" comparison is conceptually coherent because the claimed holes are formed in pillars that continue to function as photodetectors even when the holes are absent. That is, the silicon pillar itself absorbs light via its P-I-N junction, and the holes further enhance that absorption; removing the holes reduces but does not eliminate the photon-absorption function of the pillar. In my opinion, applying the '948 Patent's "like photodetector" framework to Kuboi's hybrid device, in which photoelectric conversion occurs exclusively in the organic film within the holes, is technically inappropriate because the two device architectures are not analogous: Kuboi's "holes" are the photosensing elements, not microstructures that enhance photosensing in an underlying silicon layer.

127. In my opinion, 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.

128. **Second**, in my opinion, Dr. Lebby's analysis 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 "the 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. In my opinion, this argument is conclusory and rooted in hindsight. 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.

129. In my opinion, this methodology is the definition of hindsight: Dr. Lebbby looked to the '948 Patent's specification, which expressly describes the microstructure-based absorption enhancement mechanism and provides an equation derived from high contrast grating (HCG) theory, and then reverse-engineered an analysis of Kuboi's very different structure using the '948 Patent's own framework. A POSITA reading Kuboi in isolation, without the benefit of the '948 Patent's disclosure, would have no basis to apply HCG theory or the '948 Patent's absorption-enhancement equations to Kuboi's hybrid organic-silicon pixel design, because Kuboi does not invoke HCG effects, does not describe microstructure-enhanced absorption in silicon, and does not rely on any of the optical mechanisms that the '948 Patent identified as responsible for the claimed absorption enhancement. See my discussion below about the multiple physical mechanisms contribute to the increased efficiencies introduced by the claimed microstructures; *see* '948 Patent at 9:4-8; 8:37-65, 11:52-57, 8:10-9:14.

130. **Third**, I note that Samsung cites 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). I have reviewed Han's Fig. 4, which 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. In my opinion, 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. I note that Samsung offers 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.

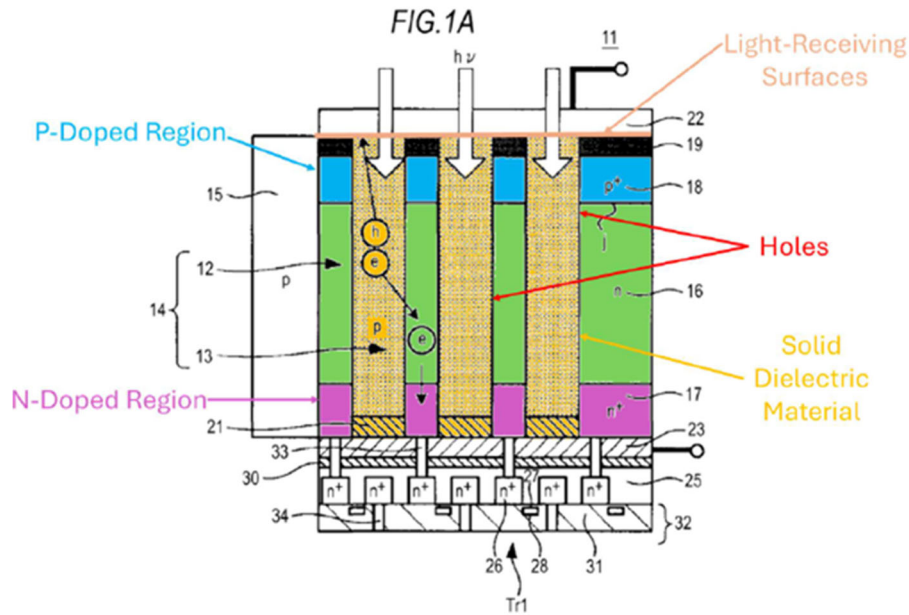
131. Based on my review of Han (Ex. 1038), the reference discloses silicon nanohole and nanorod array structures designed to improve light trapping in photovoltaic (solar cell) applications, and calculates “ultimate efficiency” (i.e., a metric based on solar spectrum photon flux) as a function of array thickness, lattice constant, and fill fraction for free-standing nanohole arrays versus nanorod arrays versus homogeneous crystalline silicon film. Ex. 1038 at 4:20-25. In my opinion, Han's nanohole structures are geometrically and functionally different from the "holes that are fabricated as recesses at or under the light-receiving surface" of Si/Ge/SiGe photodetector pillars as recited in the Challenged Claims. Han does not describe in-pillar holes; it describes arrays of through-holes in a standalone silicon thin film, with no pillars, no P-I-N junction, no reverse bias, and no integration with a CMOS detector circuit. Samsung provides no technical bridge between Han's ultimate-efficiency calculation for a free-standing photovoltaic nanohole array and the question of whether Kuboi’s organic-filled openings (in a hybrid

pixel where silicon is shielded from light) achieve the claimed 1.1x absorption increase in a Si/Ge/SiGe photodetector relative to a like photodetector lacking such holes. In my opinion, Han therefore adds nothing of probative value to Samsung's theory and cannot substitute for an actual disclosure in Kuboi of in-pillar microstructures that enhance absorption in an inorganic Si/Ge/SiGe photodetector by at least a factor of 1.1.

132. For these reasons, it is my opinion that Samsung fails to show that any of its asserted grounds disclose or achieve the claimed improvement in light absorption.

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

133. Based on my technical review, it is my opinion that 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. I have reviewed Samsung’s contention that “electron blocking film 21 and photoelectric conversion film 13 together entirely fill Kuboi’s holes and are solid dielectric materials” (Pet. at 31), and in my opinion, this contention is incorrect for multiple reasons.



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

134. **First**, in my opinion, 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 understanding is consistent with 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). In my opinion, Kuboi’s thin SiO₂ liner followed by an organic material bulk fill would not satisfy this limitation.

135. Based on my understanding of the specification, 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:

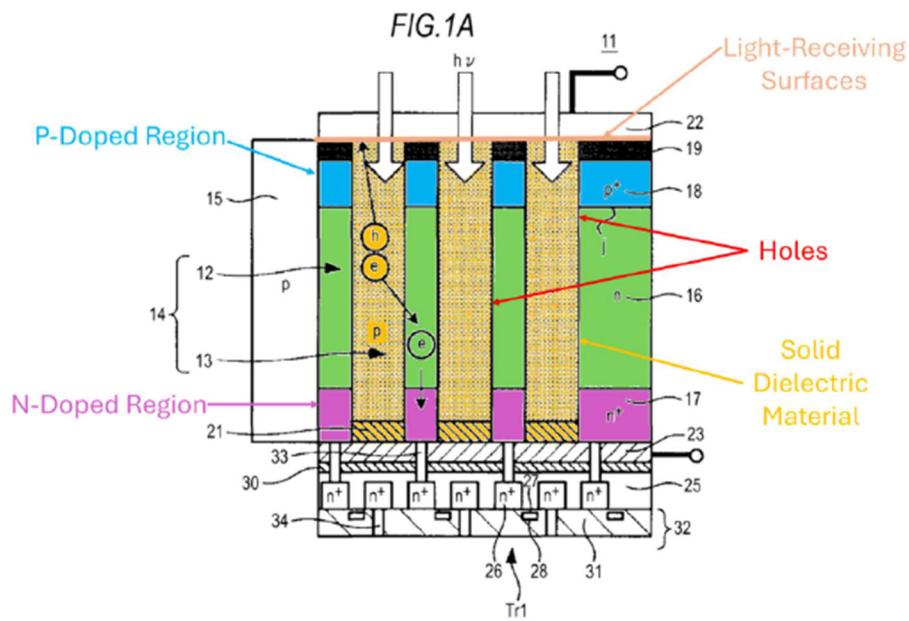
In FIG. 9D a filler 916 is used to *fill or partially fill the space* between the Si pillars 914 to support subsequent contact layers to be deposited. The filler 916 can be spin on glass, polyimide, dielectric such as silicon nitride, or silicon oxide, that can be deposited for example using plasma enhanced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

136. In my opinion, 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 increase light absorption (via high contrast grating effects). *See, e.g.,* '948 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. Thus, 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.

137. In my opinion, Kuboi's holes 38 are not "filled at least partly" with electron blocking film 21. Based on my review, the 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).

138. Accordingly, in my opinion, holes 38 are not “filled at least partly with solid dielectric material”; rather, they are fully filled with semiconducting material. Kuboi at [0073]. Based on my understanding of Kuboi’s design, the 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].

139. **Second**, because Kuboi’s electron blocking film 21 does not at least partly fill holes 38—at best it coats the bottom of the alleged hole—I understand that Samsung takes the 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]). In my opinion, they are not.

140. In my opinion, 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”). I note that 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”). In my opinion, 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*).

141. I also note that Kuboi itself mentions a Japanese Patent publication JP Patent 3423279 to Hiramoto (I will refer to it as “Hiramoto”) that establish that organic photoconversion films are 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]. Then, Kuboi states that its organic layers may include “*perylene*-based compounds, *phthalocyanine* compounds.” *id.* at [0058] (emphasis added).

142. I reviewed a machine translation of Hiramoto, and I note that it discloses that those layers are semiconducting materials, not dielectrics, which is

consistent with a POSITA's understanding of these compounds. 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, in my opinion, Kuboi's organic films are not dielectrics. Based on my understanding of Kuboi's device, the 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 the organic material generates in response to impinging light.

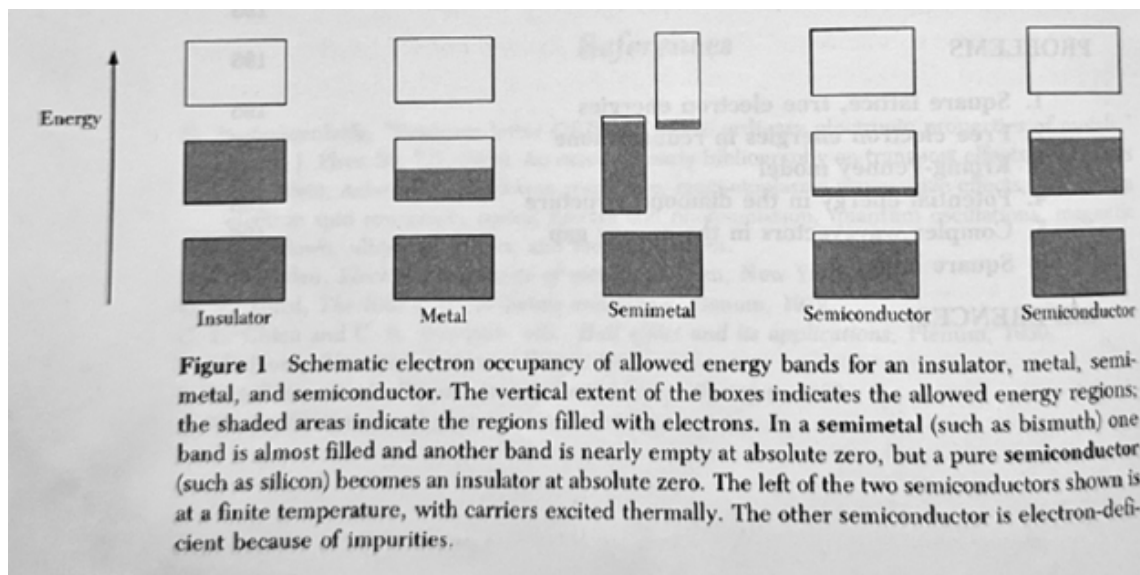
143. In view of the foregoing, it is my opinion that Dr. Lebby's claim that a "POSITA would have understood that phthalocyanine, perylene-based, and porphyrin compounds are solid dielectric materials" is incorrect and contradicted by the cited reference itself. Pet. at 30-31 (citing Lebby Decl., ¶¶ 150-152). I have reviewed Dr. Lebby's declaration, and in my opinion, his position is based on the incorrect notion that any material with a "dielectric constant" or "dielectric properties" is a dielectric material. Ex. 1002 ("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”). I note that 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.

144. Accordingly, in my opinion, although semiconductors can have non-zero dielectric constants and measurable “dielectric properties,” they are not dielectric materials because they are not insulators:

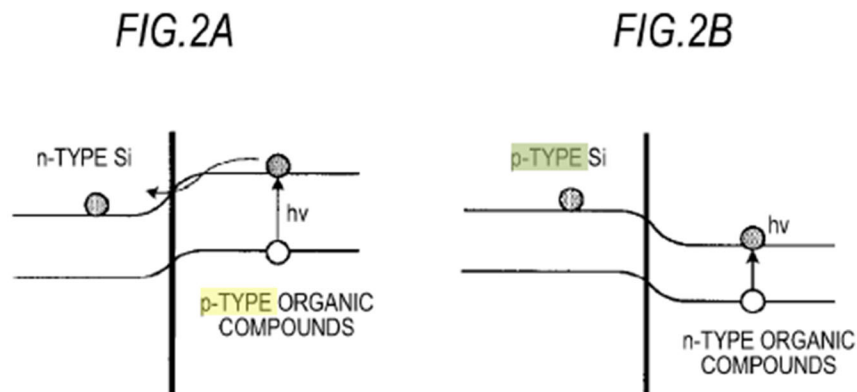
The crystal behaves as an insulator if the allowed energy bands are either filled or empty, for then no electrons can move in an electric field. The crystal behaves as a metal if one or more bands are partly filled, say between 10 and 90 percent filled. The crystal is a semiconductor or semimetal if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

145. Based on my review, 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]. In my opinion, organic semiconductors that are doped to be p-type or n-type and that carry signal charges are, by definition, 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.”).

146. I note that 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. I also note that Dr. Lebby conceded that a POSITA “wouldn't characterize a semiconductor material as a dielectric material.” Lebby Tr. at 127:8-9; *see also id.* at 126:15-17 (“to me, a semiconductor is a semiconductor, and a dielectric material is a dielectric material”). In my opinion, a POSITA would understand that a semiconductor being studied for its polarization response does not thereby become a dielectric material.

147. In my opinion, 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 123:20-124:4. 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 an insulated mode or it’s in a conductive mode, for example.” Lebbby Tr. at 141:2-5.

148. In my opinion, this variable behavior is akin to semiconductor material, which a POSITA understands is not a dielectric material. During cross-examination, Dr. Lebbby 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.*

Lebbby Tr. at 32:12-22 (emphasis added). I also note that Dr. Lebbby testified that “[i]n 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.*” Lebbby Tr. at 31:1-7 (emphasis added).

149. In my opinion, this description of a material that is insulating in the dark and conducting under illumination is the textbook definition of a photoconductive semiconductor. Photoconductivity is the phenomenon by which light generates free charge carriers in a semiconducting material, thereby increasing its electrical conductivity. A true dielectric material does not exhibit photoconductivity in this manner because, by definition, it lacks the partially filled energy band structure needed to generate and transport free charge carriers in response to photon absorption.

150. As I noted above, insulators (i.e., dielectrics) have allowed energy bands that are either fully filled or fully empty, meaning electrons cannot move freely in an electric field. Ex. 2025 (Kittel) at 7. Semiconductors, by contrast, have “one or two bands [that] are slightly filled or slightly empty,” which is precisely what enables carrier generation and transport under optical excitation. Dr. Lebby correctly acknowledged that a semiconductor material is not a dielectric material. Lebby Tr. at 127:8-9. Yet his analysis proceeds to classify Kuboi’s photoactive organic materials, which generate and transport charge carriers under illumination, as “solid dielectric materials,” a position that is directly contradicted by his own technical testimony about their conducting behavior. In my opinion, a 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.

151. For these reasons, it is my opinion that 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)

152. Based on my review, Vasylyev and Shinohara do not disclose any of the claim limitations shown above to be missing from Kuboi. *See* §§ IX.B-C, X.A-F. I understand that Petitioners do not rely on or allege Vasylyev or Shinohara as providing these limitations. Accordingly, it is my opinion that, for at least the reasons discussed above, Vasylyev and Shinohara fail to cure the deficiencies of Kuboi and that, even if a POSITA were properly motivated to make such a combination, the combination would not yield the claimed invention.

XI. THE ’948 PATENT IS ENABLED BY ITS SPECIFICATION (GROUND 5)

153. In my opinion, the Challenged Claims are enabled because the specification of the ’948 Patent teaches a POSITA how to make and use the claimed invention. I note that Samsung itself relies on explanations found in the ’948 Patent specification in its Petition. Pet. at 46-47; *see also id.* at 4-6. Based on my technical review, Samsung’s allegation that the Challenged Claims lack

enablement is inconsistent with the disclosures in the specification and fundamentally misreads the claim language. I discuss my technical basis for these opinions below.

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

154. I have been informed by counsel that to establish a lack of enablement, Samsung must show that a person of ordinary skill in the art would not be able to practice the claimed invention without undue experimentation. In my opinion, Samsung does not identify any deficiency in the '948 Patent's specification that would prevent a POSITA from making or using the claimed invention.

155. *First*, I understand that Samsung argues the claims are not enabled if “the prior art’s disclosure is deemed insufficient.” Pet. at 139-140. In my opinion, this argument is technically unfounded. As I have established above, Kuboi has an entirely different design for light detection than the '948 Patent. Based on my technical review, Kuboi does not purport to rely on the high contrast grating (HCG) effect or any of the microstructure-based absorption enhancement mechanisms disclosed in the '948 Patent. Accordingly, in my opinion, Samsung is wrong to assume that a deficiency in Kuboi’s disclosure “necessarily” establishes an enablement issue with the '948 Patent’s specification.

156. I have been informed by counsel that Samsung's conditional argument conflates the sufficiency of prior art disclosure in satisfying the Challenged Claims with the enablement of the Challenged Claims, and that these are distinct legal inquiries. I understand that prior art sufficiency for anticipation or obviousness asks whether the prior art *discloses* a limitation to a POSITA, whereas 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. In my opinion, the fact that Kuboi may or may not satisfy the 1.1x light absorption limitation says nothing about whether a POSITA could achieve that threshold using the '948 Patent's specification, because the two inquiries address different documents and different technical questions.

157. ***Second***, in my opinion, 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. I note that Samsung does not dispute that the '948 Patent enables embodiments having a single in-pillar hole. Pet. at 140. Samsung also does 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.*

158. In my opinion, Samsung incorrectly assumes 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”). Based on my review of the specification, this assumption is incorrect. 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. In my opinion, 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 8:10-9:14 (generally).

159. In my opinion, Samsung’s 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. I have reviewed Samsung's expert declaration on this point, and Dr. Lebby offers only 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 the enablement argument. Lebbby Decl. ¶ 362 (citing Ex. 1051, 1-6). Based on my review, the academic paper's subject matter concerns vertical cavity surface-emitting lasers (VCSELs), and its discussion does not raise doubts that a POSITA would have been able to practice the full scope of the Challenged Claims. Ex. 1051, Abstract. In my opinion, Samsung fails 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

160. Based on my review of the prosecution history of Application No. 19/036,506 ("the '948 Divisional"), there is no merit to Samsung's allegation of lack of enablement based on the Examiner's rejection of the '948 Divisional for lack of enablement, because the Examiner withdrew this rejection in response to W&Wsens' explanations and arguments during prosecution. Pet. at 141-142; 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)).

161. I have reviewed the record showing that W&Wsens previously 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. In my opinion, these disclosures provide sufficient guidance for a POSITA to practice the claimed invention without undue experimentation. 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.

162. In view of the foregoing, it is my opinion that the file history of the W&Wsens patent family confirms that the Office considered these enablement issues and found the Challenged Claims to be enabled. Based on my technical review, Samsung fails to show that it is more likely than not that the ’948 Patent claims are not enabled.

* * * * *

163. I declare that all statements made herein on my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Dated: May 12, 2026



Brian D'Andrade, Ph.D

APPENDIX A



Brian D'Andrade, Ph.D., P.E.

Electronics, Management, Networks, Power, Safety, Software

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Professional Profile

Dr. D'Andrade is a professional electrical, electronics, software quality, and computer engineering consultant with 20 years of experience in research, development, risk assessment, and design in a variety of engineering fields including power, app development, semiconductor, software, and network. His expertise is used in a variety of litigation, mediation, and arbitration matters including patent, copyright, trade secret, antitrust, and commercial. He investigates the technical aspects of claims related to contract disputes, fire, flood, misrepresentations, natural disasters, personal injury, project management, and software engineering.

He applies engineering principles in his consulting practice to assess how electronic products, electrical systems or software systems fail due to defects, poor development practices, or other stressors exceeding specifications. For example, he investigates failures involving electrical and electronic systems including consumer appliances, smart home devices, network equipment, lighting, building wiring, shock and arc-flash hazards, batteries, and motors in residential homes, apartments, universities, solar farms, data centers and commercial buildings. His risk assessments are based on laboratory tests and compliance to product standards and good practices.

He has 20 years of commercial experience in the semiconductor field including consulting on, research and development of light-emitting diodes (LEDs). He has reviewed numerous semiconductor recipes for GaN, OLED, and non-volatile (Flash) memories in trade-secret and patent matters. Additionally, he has extensive experience on flat panel display (FPD) technologies including thin-film-transistors, pixel circuits, barrier coatings, and FPD manufacturing tools. His wide band-gap semiconductor experience includes intellectual property litigation matters on MOCVD and MBE growth methods, doping and device architectures. His non-volatile memory work experience includes shallow trench isolation, interlayer dielectrics, spacers, and other flash memory structures for either patent or trade secret litigation matters.

In addition, Dr. D'Andrade consults on software, network, and computer engineering issues. In terms of software engineering, Dr. D'Andrade helps clients navigate software requirements, installation, contract requirements, fraudulent marketing, and operational issues. He has assessed operational algorithms for embedded systems, various industrial control systems, and smart devices. In terms of computer engineering, Dr. D'Andrade has experience with enterprise network architectures, geolocation services, domain name system, email systems, Unified Communications, cybersecurity, digital forensics, copyright, trade secret, TPM, and memory storage.

Dr. D'Andrade has also examined apps to assist on copyright and intellectual property matters. He has examined control systems, medical, enterprise resource planning, legal, blockchain, television, email, and database software systems, for example. He has also examined various networked device traffic information to determine details of the communication between servers and clients including analyzing cell-tower communications, geolocation data and time logs.

Brian D'Andrade, Ph.D., P.E.

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Academic Credentials & Professional Honors

IEEE-SA Cloud Working Group Award, 2020

Certificate of Appreciation for Leadership and Service to the American Society for Quality, 2016

New York Intellectual Property Law Association's Inventor of Year, 2015

United States Department of Energy, Significant R&D Achievement, 2006-2008.

Ph.D., Electrical Engineering, Princeton University, 2004

M.A., Electrical Engineering, Princeton University, 2001

B.S.E.E., Electrical Engineering, Pennsylvania State University, *with honors and highest distinction*, 1999

Licenses and Certifications

Project Management Professional (PMP)

Certified Associate Software Developer (CSDA)

Certified Cisco Network Professional (CCNP) - Inactive

Certified Cisco Network Professional- Security (CCNP-S) - Inactive

Certified Ethical Hacker (CEH) - Inactive

Certified Fire and Explosion Investigator (CFEI)

Certified Information Systems Security Professional (CISSP)

Certified Institute for Printed Circuits Specialist (CIS) - Inactive

Certified Reliability Engineer (CRE)

Certified Software Quality Engineer (CSQE)

Certified Electrical Safety Compliance Professional (CESCP)

Committee on National Security Systems (CNSS) 4013 Recognition

Licensed Professional Engineer, California, E 23364 (Electrical Engineering)

Licensed Professional Engineer, Colorado, #PE.0051324 (Electrical Engineering)

Licensed Professional Engineer, Connecticut, #28005 (Electrical Engineering) - Inactive

Licensed Professional Engineer, District of Columbia, PE906800 (Electrical Computer Power)

Licensed Professional Engineer, Florida, 76547 (Electrical Engineering)

Licensed Professional Engineer, Georgia, PE041462 (Electrical Engineering)

Licensed Professional Engineer, Idaho, P-17072 (Electrical Engineering)

Licensed Professional Engineer, Kentucky, 39550 (Electrical Engineering)

Licensed Professional Engineer, Maryland, #39671 (Electrical Engineering)

Licensed Professional Engineer, Massachusetts, #49411 (Electrical Engineering)

Licensed Professional Engineer, Michigan, 6201064867 (Electrical Engineering)

Licensed Professional Engineer, New Hampshire, 15508 (Electrical Engineering)

Licensed Professional Engineer, New Jersey, 24GE05246700 (Electrical Engineering)

Licensed Professional Engineer, New Mexico, 23717 (Electrical Engineering)

Licensed Professional Engineer, New York, #088186-1 (Electrical Engineering)

Licensed Professional Engineer, North Carolina, #040606 (Electrical Engineering)

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Licensed Professional Engineer, Pennsylvania, #PE083596 (Electrical Engineering)
Licensed Professional Engineer, South Carolina, #37088 (Electrical Engineering)
Licensed Professional Engineer, Virginia, 0402052671 (Electrical Engineering)
Principles of Fire Investigation Multi-Program, CFITrainer.Net IAAI
U.S. Soccer National D Coaching License

Experience

D'Andrade PhD Consulting, 2023-Present
Center for Cyber Safety and Education, 2018-Present
US Department of Energy Peer Reviewer, 2011-Present
Research Grants Council Peer Reviewer, 2004-Present
Principal Engineer, Exponent, Inc, 2008-2023
Senior Scientist, Universal Display Corporation, 2004-2008
Research Assistant, Princeton University, 1999-2004
Teaching Assistant, Princeton University: wireless communication, and electronic devices, 2000-2001.
Research Assistant, Massachusetts Institute of Technology: materials development, 1998
Teaching Assistant, Pennsylvania State University: calculus, signal processing, 1997-1998
Electrical Engineering Co-op, Kimberly-Clark Corporation: industrial controls, inventory tracking, 1997

Professional Affiliations

IEEE (member: 2008-2025)
IEEE Standards Association (member: 2016-2024)
IEEE Std. 2302 – Standard for Intercloud Interoperability and Federation – (Balloter)
IEEE Std. 2301 - Guide for Cloud Portability and Interoperability Profiles - (Chair: 2017-2023)
ISC²-National Chapter Region (Secretary: 2016-2019; President: 2020-2022)
International Information System Security Certification Consortium (ISC)² (member)
National Fire Protection Association (member: 2010-2024)
National Association of Fire Investigators (member: 2010-2024)
Project Management Institute (member)
St. Pius X Parish Finance Council (2018-2024)

Publications

D'Andrade B. The Sustainable Power Grid: Challenges, Applications, and Case Studies. D'Andrade B (ed), Academic Press, 2024.
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IEEE Std. 2302:- Standard for Intercloud Interoperability and Federation (SIIF), IEEE-SA, 2021
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IEEE Std. 2301: Guide for Cloud Portability and Interoperability Profiles (CPIP). IEEE-SA, 2020

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Patents

100+ Patents Worldwide.

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Patent 9,349,954: Stable blue phosphorescent organic light emitting devices, May 24, 2016.

Patent 9,112,171: Organic light emitting device and materials for use in same, August 18, 2015.

Patent 8,866,377: Long lifetime Phosphorescent OLED Structures, October 21, 2014.

Patent 8,557,399: Stable blue phosphorescent organic light emitting devices, October 15, 2013.

Patent 8,513,658: White phosphorescent organic light emitting devices, August 20, 2013.

Patent 8,476,822: Saturated color organic light emitting devices, July 2, 2013.

Patent 8,372,526: Intermediate connector for stacked organic light emitting devices, February 12, 2013.

Brian D'Andrade, Ph.D., P.E.

04/14/2026

Patent 8,148,891: Electron impeding layer for high efficiency phosphorescent OLEDs, April 3, 2012.

Patent 8,080,937: OLED having a charge transport enhancement layer, December 20, 2011.

Patent 8,053,770: Emissive Layer Patterning for OLED, November 08, 2011.

Patent 8,040,053: Organic light emitting device architecture, October 18, 2011.

Patent 7,800,295: Organic light emitting device having a microcavity, September, 2010

Patent 7,776,456: Organic light emitting devices with an emissive region having emissive and non-emissive layers and method of making, August 17, 2010.

Patent 7,728,512: Organic light emitting device having an external microcavity, June 1, 2010.

Patent 7,710,017: Organic light emitting device having a transparent microcavity, May, 2010.

Patent 7,285,907: High efficiency multi-color electro-phosphorescent OLEDs, October 2007.

Patent 7,261,954: Organic light emitting devices having carrier blocking complexes, August 2007.

Patent 7,179,543: Doping of organic opto-electronic devices to extend reliability, February 2007.

Patent 7,022,421: Organic light emitting devices having carrier blocking layers, April 2006.

Patent 7,009,338: High efficiency multi-color electro-phosphorescent OLEDs, March 2006.

Patent 6,869,695: White OLEDs from combined monomer and aggregate emission, March 2005.

Patent 6,863,997: White OLEDs from combined monomer and aggregate emission, March 2005.

US 20070103066: Stacked OLEDs with a reflective conductive layer, filed November 4, 2005

Project Experience

- Cause and origin fire investigations for consumer product retailers.
- Cause and origin fire investigations involving utility equipment.
- Cause and origin for investigations of computer, network and research equipment related to flooding.
- Due diligence review of medical equipment, manufacturing systems, and consumer electronics.
- Engineer in responsible charge for various electro-magnetic field studies for public power utilities.
- Performing risk assessment of PCB designs for medical, lighting, consumer electronic systems.

Communication Networks

- Analyzing software and hardware involved in cyber-security insurance claims.
- Domain Name System (DNS).
- Failure analysis of residential cable modems. Intellectual property/patent investigations of networks including Zigbee, Extranet, Internet, Intranet, VPN, WAN and LAN.
- Investigate physical damage to hardware by malware.
- Networking load balancing.
- Patent portfolio review.
- Patent re-examinations.
- Programmed routers and switches for small to medium sized enterprises.

Electrical Power

- Arc-flash, electrocution, shock
- Bonding and insulation piercing connectors.
- Electrical safety and personal injury investigations.
- Failure investigation at solar power farms.
- Installation and Megger testing of power cables.
- Installation of multi-cell conduit.
- Inverter failure analysis.
- Power utility meters.

Brian D'Andrade, Ph.D., P.E.

04/14/2026

- Root-cause analysis of power outages in large data center facilities.
- Solar generation system operational analysis
- Switch gear failures.
- Testing of circuit breakers.
- Transmission lines.

Semiconductors

- Intellectual property analysis
- Memory technology analysis.
- MOCVD recipe analysis.
- Production materials utilization and sourcing.
- Semiconductor packaging design, processing, and failure analysis.
- Solar PV module reliability.

Software

- App design and development.
- Algorithm review.
- Software Engineering.
- Aviation maintenance, repair, and operations software installation.
- Copyright infringement analysis of source code.
- Domain Name System.
- Enterprise resource planning.
- GPS, geofence, geolocation, and related technologies.
- Health insurance, television network, and criminal case management software systems.
- Investigating alleged ITAR violations in software products for a military contractor.
- Project management good practices.
- Push Notification.
- Smartphone forensics.
- Sports Service Betting Terminals
- SQL design, development, and construction.

Standards and Regulations

- 47 CFR Part 15 – Radio Frequency Devices
- ANSI/UL 2900-1 – Software Cybersecurity for Network-Connectable Products
- ANSI C12.1 - Electric Meters Code for Electricity Metering
- ANSI C12.10 - Physical Aspects of Watthour Meters - Safety Standard
- ANSI C63.4 - Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
- ANSI/PMI 99-001-2017 - A Guide to the Project Management Body of Knowledge
- ASTM B117-11 - Standard Practice for Operating Salt Spray (Fog) Apparatus
- ASTM E860-07 - Standard Practice for Examining And Preparing Items That Are Or May Become Involved In Criminal or Civil Litigation
- ASTM E1188-11 - Standard Practice for Collection and Preservation of Information and Physical Items by a Technical Investigator
- ASTM E1459-92 - Standard Guide for Physical Evidence Labeling and Related Documentation
- BS 7671 - Requirements for Electrical Installations. IET Wiring Regulations
- IEC 60320 – Appliance Couplers for Household and Similar General Purposes
- IEC 60227 - Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V
- IEC 60228 - Conductors of Insulated Cables
- IEEE Std 828 – IEEE Standard for Configuration Management in Systems and Software Engineering
- IEEE Std 829 – IEEE Standard for Software and System Test Documentation
- IEEE Std 830 – IEEE Recommended Practice for Software Requirements Specifications
- IEEE Std 1016 – IEEE Standard for Information Technology – Systems Design

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- IEEE Std 1228 – IEEE Standard for Software Safety Plans
- IEEE Std 1633 – IEEE Recommended Practice on Software Reliability
- IEEE C37.90.1 - IEEE Standard for Surge Withstand Capability (SWC) Tests For Relays And Relay Systems Associated With Electric Power Apparatus
- IEEE C62.11 - IEEE Standard for Metal-Oxide Surge Arresters For AC Power Circuits (>1 KV)
- IEEE Std 1 - General Principles for Temperature Limits in the Rating of Electrical Equipment and for the Evaluation of Electrical Insulation
- IEEE Std 1028 – IEEE Standard for Software Reviews and Audits
- IEEE Std C62.41.2 - IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits
- IEEE Std 1547 - IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
- ISO 27037 - Information Technology - Security Techniques - Guidelines for Identification, Collection, Acquisition and Preservation of Digital Evidence
- ISO 17025 - General Requirements for The Competence of Testing and Calibration Laboratories
- ISO 27000 series - IT - Security Techniques - Information Security Management Systems
- ISO/IEC 33000 series – Information technology – Process assessment
- ISO 15801 - Document Management - Electronically Stored Information - Recommendations for Trustworthiness and Reliability
- ISO TR 19759 - Software Engineering Guide to the software engineering body of knowledge (SWEBOK)
- ISO 33000 series - Process Assessment
- NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- NESC – The National Electric Safety Code
- NFPA 70 – National Electric Code
- NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
- NFPA 70E – Standard for Electrical Safety in the Workplace
- NFPA 921 – Guide for Fire and Explosion Investigations
- TCVN 7189 - Radio disturbance characteristics – Limits and methods of measurement
- UL 1097 – Double Insulation Systems
- UL 1310 – Class 2 Power Units
- UL 1449 - Standard for Surge Protective Devices
- UL 1703 - Standard for Flat-Plate Photovoltaic Modules and Panels
- UL 1741 - Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources
- UL 2735 -Standard for Electric Utility Meters
- UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
- UL 50 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
- UL 508 - Standard for Industrial Control Equipment
- UL 60950-1 - Information Technology Equipment - Safety
- UL 61010-1 - Safety Requirements for Electrical Equipment for Measurement, Control, and Lab. Use
- UL 746C - Standard for Polymeric Materials - Use in Electrical Equipment Evaluations
- UL 817 - Standard for Cord Sets and Power-Supply Cords
- UL 962 – Standard for Safety – Household and Commercial Furnishings

Training

Complete iOS App Development Bootcamp. 50-hr. program. Udemy. 2025.

Ultimate C# Masterclass. 20-hr program. Udemy. 2025.

Building a Hybrid Cloud Mesh Security Strategy. 1-hr program. BrightTalk. December 29, 2025.

Modern Email Security Architecture. 1-hr program. BrightTalk. November 5, 2025.

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Introducing Hyperproof AI. 1-hour program. BrightTalk. October 2025.

AI-Powered Threat Detection. 1-hour program. BrightTalk. October 2025.

Ultimate C# Masterclass. 20-hour program. Udemy. September 2025.

2023 NFPA 70B. 4-hour program. NFPA. April 2025.

How AI Will Transform Project Management. 1-hour program. PMI. March 2025.

Achieving Real Value with Zero Trust Security. 1-hour program. BrightTalk. March 2025.

Strategies to Overcome the Cybersecurity Skills Shortage. 1-hour program. BrightTalk. March 2025.

Ransomware 3.0. 1-hour program. BrightTalk. March 2025.

Governing Data in the Age of Generative AI. 1-hour program. BrightTalk. November 2024.

Security Industry 101. 1-hour program. BrightTalk. November 2024.

AI at Its Best: US Navy Explores LLM Trust. 1-hour program. BrightTalk. November 2024.

Data-Centric Communications. 1-hour program. BrightTalk. October 2024.

A Strategic Approach to PCI Requirements Compliance. 1-hour program. BrightTalk. September 2024.

AI to run the real world. 1-hour program. BrightTalk. September 2024.

Optimizing Costs in Your Data Workflow. 1-hour program. BrightTalk. August 2024.

Making Decisions in a Cyber Crisis. 1-hour program. August 2024.

Multiple Personalities: Making Decisions In a Cyber Crisis. 1-hour program. August 2024.

An Executive's Guide to Disciplined Agile. 1-hour program. PMI. June 2024.

It's Hard Being Agile While Getting Drenched in a Waterfall. 1-hour program. PMI. June 2024.

Exploring Five Emerging Cybersecurity Defenses. 1-hour program. BrightTalk. June 2024

Key Insights From the 2024 Cyberthreat Defense Report. Brighttalk. June 2024.

SonicWall & You: New Era, New Opportunities. 1-hour program. BrightTalk. June 2024.

Why Digital Transformation Requires Security Transformation. 1-hour program. BrightTalk. July 2025.

NFPA 70E, Electrical Safety in the Workplace (2024). 16-hour program. NFPA. May 2024.

Modern App Delivery & Security with BIG-IP Next. 1-hour program. BrightTalk. May 2024.

Cloud, automation and AI shaping the future of finance. 1-hour program. BrightTalk. April 2024.

Getting to know the Disciplined Agile Coach. 1-hour program. PMI. April 2024.

Disciplined Agile Data Management. 1-hour program. PMI. April 2024.

How to De-Risk Your ERP Project. 1-hour program. BrightTalk. April 2024.

Trends from Hyperproof's 2024 IT Risk and Compliance. 1-hour program. BrightTalk, April 2024.

Principles in Project Portfolio Management. 1-hour program. PMI. March 2024.

How AI Will Power Enterprise Architecture. 1-hour program. BrightTalk, March 2024.

Emerging Network Security Tools. BrightTalk, March 2024.

Getting to know the Disciplined Agile Senior Scrum Master. 1-hour program. PMI. March 2024.

Hybrid Project Management: Fit-for-Purpose to Drive Performance. 1-hour program. PMI. March 2024

How to Augment Your Microsoft 365 Security. 1-hour program. BrightTALK. February 2024.

Top Five Cybersecurity Predictions for 2024. 1-hour program. BrightTALK. February 2024.

Security Industry 101. 1-hour program. BrightTALK. February 2024.

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AI "Meeting Minute" Generators. 1-hour program. PMI. February 2024

An Introduction To the DA Value Stream Consultant. 1-hour program. PMI. February 2024

The Inside Scoop on the PMI Citizen Developer Handbook. 1-hour program. PMI. February 2024

Innovation Narratives and Leadership. 1-hour program. PMI. January 2024

Disciplined Agile and Value Streams. 1-hour program. PMI. January 2024

NFPA 70E, Electrical Safety in the Workplace (2024). 16-hour program. NFPA. October 2023

Physical Evidence at the Fire Scene. 4-hour program. CFITrainer.Net. October 2023

The Scientific Method for Fire and Explosion Investigation. 3-hour program. CFITrainer.Net. October 2023

Safe Electrical Work Practices (NFPA 70E). National Fire Protection Association. September 2023.

Residential Natural Gas Systems. 3-hour program. CFITrainer.Net. August 2023.

Residential Electrical Systems. 4-hour program. CFITrainer.Net. August 2023.

Overview of National Cybersecurity Strategy 2023. 2-hour presentation. National Capital Region (ISC²). July 2023.

Critical Infrastructure Cybersecurity: Past, Present, and Future. 2-hour presentation. National Capital Region (ISC²). June 2023

Unlocking AI's Potential: Exploring the Exciting World of Artificial Intelligence. 2-hour presentation. National Capital Region (ISC²). April 2023.

Cybersecurity 2023 Outlook. 2-hour presentation. National Capital Region (ISC²). March 2023.

NFPA 1033 and Your Career. 2-hour course. International Association of Arson Investigators, Inc. Online. March 2023.

Conflict of Interest: Recognize Potential Conflicts and Their Causes. .5-hour course. Meridian Knowledge Solutions. Online. February 2023.

Fundamentals of Interviewing. 4-hour course. International Association of Arson Investigators, Inc. Online. February 2023.

Insurance and the Fire Investigation. 4-hour course. International Association of Arson Investigators, Inc. Online. February 2023.

Insurance and the Fire Investigation. 4-hour course. International Association of Arson Investigators, Inc. Online. February 2023.

Sanctions and Trade Controls for IEEE Volunteers. 1-hour course. Meridian Knowledge Solutions Online. February 2023.

Bridging the Gap. Practical Solutions for attracting, building and retaining cybersecurity talent. 2-hour presentation. National Capital Region (ISC²). February 2023.

Understanding IEEE SA's Antitrust, Competition, and Commercial. 1-hour course. Institute of Electrical and Electronics Engineers, Inc. Online. February 2023.

Fire Investigator Scene Safety. 3-hour course. International Association of Arson Investigators, Inc. Online. January 2023.

Let's Collaborate on [Microsoft] Teams Oh my God, what have we done! 2-hour presentation. National Capital Region (ISC²). January 2023.

Maryland Engineering Laws, Rules and Ethics. 1-hour course. PDHengineer. Online. October 2022.

Effective Investigation and Testimony. 3-hour course. International Association of Arson Investigators, Inc. Online. October 2022.

Fire Chemistry. 3-hour course. International Association of Arson Investigators, Inc. Online. October 2022.

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Expert Trial Testimony

Brian Quanstrum and Lisa Quanstrum v. Flint EMC et al. Civil Action No. 2023-cv-54868. In the State Court of Houston County in the State of Georgia. Expert Deposition/Trial: November/December 2024. Expertise:- NESC, NFPA 70E, OSHA, and electrical safety and utility electrical protection devices.

In the Matter of Certain Organic Light-Emitting Diode Display Modules And Components Thereof Investigation No. 337-TA-1378, before the United States International Trade Commission. Expert Reports/Deposition/Trial. October 2024. Technology:- OLED display manufacturing including panel lamination, electrostatic chucks, evaporation and thin film encapsulation equipment, white light interferometry, flexible printed circuit boards and displays, and OLED architectures. I provided expert witness in the field of electronics product including OLED and micro-OLED design, panel manufacturing, and display processing. Additionally, I provided expert witness services on topics relating to reasonable security measures, project management and development head starts.

Ecofactor, Inc. v. ecobee, Inc. Case No. 6:21-cv-00428. In the United States District Court for the Western District of Texas. Expert Report/Deposition/Trial. November/December 2022/June 2023. Technology:- Smart Meters, Smart Thermostats, Internet of Things, Geolocation, Geofence.

In the Matter of Certain Smart Thermostats Load Control Switches, And Components Thereof. Investigation No. 337-TA-1277, before the United States International Trade Commission. Expert Report/Deposition/Trial Testimony: July 2022. Technology:- Smart Meters, Smart Thermostats

Judicial Arbitration and Mediation Services Wilmington Delaware. Expert Report/Deposition/Trial Testimony: January 2022. Technology: Email digital forensics including determining source and location of emails.

Jiaxing Super Lighting Electric Appliance Co. Ltd. and Obert, Inc. v CH Lighting Technology, Co., Ltd., Elliott Electric Supply Inc. and Shaoxing Ruising Lighting, Co., Ltd. Case No. 6:20-cv-00018-ADA. In the United States District Court for the Western District of Texas, Waco Division. Expert Report/Deposition/Trial Testimony: November 2021, 2026. Technology:- LED tube lamps.

Logitech, Inc. v. United States, Court No. 16-00017. United States Court of International Trade. Testimony: November 2019. Expert Report/Deposition/Trial. Technology:- Webcams, ConferenceCams, Television Cameras, Telecommunication Networks and Unified Communications.

Lumileds LLC v. Elec-Tech International Co., Ltd et al., Case No. 1-15-CV-278566. Superior Court of the State of California, County of Santa Clara. Testimony:- February 2019 (Bench Trial). Technology:- Light emitting diode manufactured with MOCVD.

Expert Experience

Shanghai Jinko Green Energy Enterprise Management Co. Ltd., et al. v. Waaree Solar Americas Inc. et al. 4:25-cv-532. In the United States District Court for the Southern District of Texas. 2026. Technology:- Solar modules and panels.

Judy Gravley v. Safe Step Walk-In Tub, LLC. C.A. No.: 2024-CP-23. In the State of South Carolina County of Greenville Court of Common Pleas. 2026. Expertise:- Electrical Safety.

Shanghai Jinko Green Energy Enterprise Management Co. Ltd., et al. v. Vietnam Sunergy Joint Stock Company et al. 3:24-cv-008828. In the United States District Court for the Northern District of California. Expert Reports. January 2026. Technology:- Solar modules and panels.

Taran Pietosi, et al. v. HP, Inc. et al. Case No. 3:22-cv-04273-VC (SK). In the United States District Court for the Northern District of California San Francisco Division. Expert Reports/Deposition/Deposition. December 2024/January 2025/February 2026. Technology:- Microprocessors, Trusted Platform Module, Cybersecurity, PC performance.

Algebraix LLC v. International Business Machines Corporation. 2:24-CV-00999. In the United States District Court for the Eastern District of Texas Marshall Division. 2025. Technology:- Systems and methods for data storage.

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Actian Corporation v. Sabre GBL, Inc. et al. Civil Action No. 4:24-cv-00034-O. In the United States District Court for the Northern District of Texas Forth Worth Division. Technology:- Embedded Databases.

Internet Sports International, Ltd v. Amelco USA, LLC, et al. Case No. 2:23-cv-00893-ART-NJK. In the United States District Court District of Nevada, Southern Division. Expert Reports/Deposition. May/June 2024. Technology:- Self Service Sports Betting Terminals.

Blockchain Innovation, LLC v. Franklin Resources, et al. Case No. 3:21-cv-08787-AMO. In the United States District Court District, Northern District of California, San Francisco Division. Expert Report/Deposition. June/July 2024. Technology:- Software engineering associated with implementing blockchains for a tokenized money market fund.

Mark Adam Florence v. Proctor & Gamble, el al. Civil Action No. 22-c-02652-s1. In the State Court of Gwinnett County, State of Georgia. March 2024. NFPA 70E, OSHA, NESC, electrical safety.

OSGHD, LLC, v. Nomi Health, Inc., Domo, Inc. Case No. 3:23-cv-00604-K. In the United States District Court for the Northern District of Texas. March 2024. Software copyright and trade secret matter.

Media Rights Technologies, Inc. et al v. Fifty-Five River Street Associates, LLC et al. Case No. 18CV01477. Superior Court of the State of California in and for the County of Santa Cruz. March 2024. Technology:- Audio, video, and software copyrights on media storage and server.

Palisades Property & Casualty Insurance Company and James Marchesano v. Amazon.com Inc. and John Doe Manufacturer Case No.: 2:2023cv02719. US District Court for the Eastern District of Pennsylvania. Expert. January 2024. Fire and cause investigation related to consumer products.

State Farm Fire & Casualty Ins. Co. v. Michael & Son Services, Inc. et al. Civil Action No.: CAL22-27518. In the Circuit Court for Prince George's County, Maryland. Expert Deposition. December 2023. Fire and cause investigation related to failure of conductors.

Onsite Health Diagnostics, LLC v. US Wellness, Inc., YoungSoft, Inc. Case No. 3:22-CV-02366-E. In the United States District Court for the Northern District of Texas Dallas Division. Expert Report. October 2023. Matter related to software requirements, copyright, and software contract terms.

Groove Digital, Inc., v. Jam City, Inc., C.A. No. 18-1331-RGA. In the United States District Court for the District of Delaware. Expert Reports/Deposition. February/July 2023. Matter related to software intellectual property including geolocation enabled app features on Android and iOS platforms.

Groove Digital, Inc., v. King.com, Ltd., King.com Inc., and King.com (US) LLC, C.A. No. 18-836-RGA. In the United States District Court for the District of Delaware. Expert Reports/Deposition. February/June 2023. Matter related to software intellectual property including geolocation enabled app features

OSGHD, LLC v. Nomi Health, Inc. and Agiliway Group, Inc. et al., Cause No. DC-22-03963. In the District Court of Dallas County, Texas 14th Judicial District. Expert Reports/Deposition. March-May 2023. Matter related to software engineering including development cost estimation and contractual requirements.

Carey, Administrator of the Estate of Kelvin Neil Finck, Deceased, v. A&N Electric Cooperative, Morris & Ritchie Associates, Inc., Allstate Tower, Inc., and Dietzel Enterprises Inc. Case No. 21CL338. In the Circuit Court of the County of Accomack, Virginia. Expert Report/Deposition. February/March 2023. Electrocutation matter related to OSHA, NFPA 70E, and National Electric Safety Code (NESC).

Nicholas Longo v. NSTAR Electric Company d/b/a Eversource Energy, T-C Fort Point Creative Exchange, LLC, and Transwestern Commercial Services C.A. No. 1984CV02496H, Superior Court of the Commonwealth of Massachusetts. Expert Report. September 2022. Matter related to personal injury and electric shock under OSHA, NFPA 70E, and National Electric Safety Code (NESC) standards.

Jane Doe v. Uber Technologies Inc. et al. Case No. 3:19-cv-3310-JSC. In the United States District Court for the Northern District of California, San Francisco Division. Expert Report/Deposition. May/June 2022. Technology:- Rideshare app development, geolocation, and safety.

Jiaxing Super Lighting Electric Appliance Co. Ltd. and Obert, Inc. v. Maxlite, Inc. Case No. 2:19-cv-04047-PSG. In the United States District Court for the Central District of California Western Division. Expert Report/Deposition. May/June 2022. Technology:- LED tube lamps and electronic components.

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In the Matter of Certain Smart Thermostats Load Control Switches, And Components Thereof.

Investigation No. 337-TA-1277, before the United States International Trade Commission. Expert Report/Deposition. April 2022. Technology:- Smart Meters, Smart Thermostats, Internet of Things, Utility Demand Response.

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