

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Apple Inc. and Sony Group Corporation,
Petitioners

v.

SiOnyx LLC,
Patent Owner

Inter Partes Review Case No. IPR2025-00689
U.S. Patent No. 11,721,714

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 11,721,714**

TABLE OF CONTENTS

I.	INTRODUCTION.....	1
II.	LEVEL OF SKILL OF A POSITA	1
III.	REQUIREMENTS UNDER 37 C.F.R. §42.104	2
	A. GROUNDS FOR STANDING UNDER 37 C.F.R. §42.104(A)	2
	B. IDENTIFICATION OF CHALLENGE UNDER 37 C.F.R. §42.104(B)	2
	C. CLAIM CONSTRUCTION UNDER 37 C.F.R. §42.104(B)(3).....	3
IV.	SHOWING OF ANALOGOUS, PRIOR ART	3
V.	GROUND 1: CLAIMS 1-5, 9-11 ARE OBVIOUS OVER HWANG-099	4
	A. CLAIM 1	5
	1. <i>1[Pre]: “A light trapping device, comprising:”</i>	<i>5</i>
	2. <i>1[a]: “at least one light sensitive pixel”</i>	<i>6</i>
	3. <i>1[a][i]: “having a light incident surface, a backside surface opposite the light incident surface”</i>	<i>7</i>
	4. <i>1[a][ii]: “a peripheral sidewall disposed into at least a portion of the pixel and extending at least substantially around the pixel periphery”</i>	<i>8</i>
	5. <i>1[b]: “a backside light trapping material at least partially covering the backside surface”</i>	<i>12</i>
	6. <i>1[c]: “a peripheral light trapping material substantially covering the peripheral sidewall”</i>	<i>14</i>
	a) Hwang-099’s Teachings.....	14
	b) Motivation to Combine	17
	7. <i>1[d]: “wherein light contacting the backside light trapping material or the peripheral light trapping material is reflected back toward the pixel”</i>	<i>18</i>
	8. <i>1[e]: “wherein at least one of the backside light trapping material or the peripheral light trapping material includes a high refractive index material sandwiched between two low refractive index materials.”</i>	<i>20</i>
	a) <i>Backside Light Trapping Material</i>	<i>20</i>
	b) <i>Peripheral Light Trapping Material.....</i>	<i>22</i>
	B. CLAIM 2	23
	C. CLAIM 3	23
	D. CLAIM 4	24

E.	CLAIM 5	24
F.	CLAIM 9	24
G.	CLAIM 10	24
H.	CLAIM 11	25
VI.	GROUND 2: CLAIM 6 IS OBVIOUS OVER HWANG-099 AND KOMURO	27
A.	HWANG-099'S TEACHINGS	27
B.	KOMURO'S TEACHINGS.....	27
C.	MOTIVATION TO COMBINE	28
VII.	GROUND 3: CLAIMS 7-8 ARE OBVIOUS OVER HWANG-099 AND HWANG-795.....	29
A.	CLAIM 7	29
1.	<i>Hwang-795's Teachings</i>	29
2.	<i>Motivation to Combine</i>	30
B.	CLAIM 8	31
VIII.	GROUND 4: CLAIMS 12-13 ARE OBVIOUS OVER HWANG-099 AND YAMASHITA	32
A.	CLAIM 12	32
1.	<i>Yamashita's Teachings</i>	32
2.	<i>Motivation to Combine</i>	34
B.	CLAIM 13	34
IX.	GROUND 5: CLAIMS 12, 14-15, 17 ARE OBVIOUS OVER HWANG-099 AND KONNO.....	35
A.	CLAIM 12	35
1.	<i>Konno's Teachings</i>	35
2.	<i>Motivation to Combine</i>	36
B.	CLAIM 14	37
C.	CLAIM 15	39
D.	CLAIM 17	41
X.	GROUND 6: CLAIM 16 IS OBVIOUS OVER HWANG-099, KONNO, AND KIM.....	43
XI.	GROUND 7: CLAIM 18 IS OBVIOUS OVER HWANG-099 IN COMBINATION WITH MOULI AND/OR NOZAKI	44
A.	MOULI'S SLOPED TRENCH WALL.....	44
1.	<i>Mouli's Teachings</i>	44
2.	<i>Motivation to Combine</i>	45

B.	NOZAKI’S SLOPED BACKSIDE SURFACE	46
1.	<i>Nozaki’s Teachings</i>	46
2.	<i>Motivation to Combine</i>	47
C.	OBVIOUSNESS OF COMBINING BOTH MOULI AND NOZAKI	48
XII.	GROUND 8: CLAIMS 1-5, 9-13 ARE OBVIOUS OVER HONG, YAMASHITA, AND HWANG-584	49
A.	CLAIM 1	49
1.	<i>Claim 1[Pre]: “A light trapping device, comprising”</i>	49
2.	<i>Claim 1[a]: “at least one light sensitive pixel”</i>	50
3.	<i>Claim 1[a][i]: “having a light incident surface, a backside surface opposite the light incident surface”</i>	51
4.	<i>Claim 1[a][ii]: “a peripheral sidewall disposed into at least a portion of the pixel and extending at least substantially around the pixel periphery”</i>	53
a)	Hong’s Teachings.....	53
b)	Yamashita’s Teachings	54
c)	Motivation to Combine	56
5.	<i>Claim 1[b]: “a backside light trapping material at least partially covering the backside surface”</i>	57
6.	<i>Claim 1[c]: “a peripheral light trapping material substantially covering the peripheral sidewall”</i>	59
a)	Hwang-584’s Teachings.....	59
b)	Motivation to Combine	63
7.	<i>Claim 1[d]: “wherein light contacting the backside light trapping material or the peripheral light trapping material is reflected back toward the pixel”</i>	64
a)	Hong’s Backside Light Trapping Material.....	64
b)	Hwang-584’s Peripheral Light Trapping Material.....	64
8.	<i>Claim 1[e]: “wherein at least one of the backside light trapping material or the peripheral light trapping material includes a high refractive index material sandwiched between two low refractive index materials”</i>	65
a)	Hong’s Backside Light Trapping Material.....	65
b)	Hwang-584’s Peripheral Light Trapping Material.....	69
c)	Motivation to Combine	70
B.	CLAIM 2	70
C.	CLAIM 3	70
D.	CLAIM 4	70
E.	CLAIM 5	70

F.	CLAIM 9	71
G.	CLAIM 10	71
H.	CLAIM 11	71
	1. <i>Hong's and Yamashita's Teachings</i>	71
	2. <i>Motivation to Combine</i>	73
I.	CLAIM 12	75
	1. <i>Yamashita's Teachings</i>	75
	2. <i>Motivation to Combine</i>	75
J.	CLAIM 13	75
XIII. GROUND 9: CLAIM 6 IS OBVIOUS OVER HONG, YAMASHITA, HWANG-584, AND KOMURO		76
A.	KOMURO'S TEACHINGS	76
B.	MOTIVATION TO COMBINE	76
XIV. GROUND 10: CLAIMS 7-8 ARE OBVIOUS OVER HONG, YAMASHITA, HWANG-584, AND HWANG-795.....		77
A.	CLAIM 7	77
	1. <i>Hwang-795's Teachings</i>	77
	2. <i>Motivation to Combine</i>	77
B.	CLAIM 8	78
XV. GROUND 11: CLAIM 11 IS OBVIOUS OVER HONG, YAMASHITA, HWANG-584, AND MOULI		78
A.	HONG'S AND MOULI'S TEACHINGS	78
B.	MOTIVATION TO COMBINE	80
XVI. GROUND 12: CLAIMS 12, 14-15, 17 ARE OBVIOUS OVER HONG, YAMASHITA, HWANG-584, AND KONNO		82
A.	CLAIM 12	82
	1. <i>Konno's Teachings</i>	82
	2. <i>Motivation to Combine</i>	82
B.	CLAIM 14	83
C.	CLAIM 15	83
D.	CLAIM 17	84
XVII. GROUND 13: CLAIM 16 IS OBVIOUS OVER HONG, YAMASHITA, HWANG-584, KONNO, AND KIM		85
XVIII. GROUND 14: CLAIM 18 IS OBVIOUS OVER HONG, YAMASHITA, AND HWANG-584 IN COMBINATION WITH MOULI AND/OR NOZAKI.....		85

A.	HONG’S SLOPED TRENCH WALL	85
B.	MOULI’S SLOPED TRENCH WALL.....	86
C.	NOZAKI’S SLOPED BACKSIDE SURFACE	87
D.	OBVIOUSNESS OF COMBINING BOTH MOULI AND NOZAKI	88
XIX.	DISCRETIONARY DENIAL	88
A.	§314(A): GENERAL PLASTIC	88
1.	<i>Factor 1</i>	88
2.	<i>Additional General Plastic Factors</i>	92
B.	§325(D): ADVANCED BIONICS	94
C.	§314(A): <i>FINTIV</i>	95
XX.	CONCLUSION.....	96
XXI.	MANDATORY NOTICES UNDER 37 C.F.R. § 42.8(A)(1)	97
A.	REAL PARTY-IN-INTEREST	97
B.	RELATED MATTERS	97
1.	<i>District Court Litigation Matters</i>	97
2.	<i>ITC Matters</i>	97
3.	<i>IPR Matters</i>	98
C.	LEAD AND BACK-UP COUNSEL	98
D.	37 C.F.R. § 42.8(B)(4) – SERVICE INFORMATION	99

TABLE OF AUTHORITIES

Cases

<i>Alivecor v. Apple</i> , IPR2023-00950, Paper 12, 51-54 (PTAB Jan. 9, 2024)	97
<i>Am. Honda Motor Co., Inc. v. Intellectual Ventures II</i> , IPR2018-00348, Paper 10, 19-20 (PTAB Jun. 27, 2018)	95, 96
<i>Apple Inc. v. Theta IP, LLC</i> , IPR2024-00819, Paper 12, 17 (PTAB Nov. 26, 2024)	94
<i>Ascend Elements, Inc. v. Duesenfeld GmbH</i> , IPR2024-00948, Paper 10, 32-34 (PTAB Nov. 22, 2024)	94
<i>Ford Motor Co. v. Neo Wireless LLC</i> , IPR2023-00763, Paper 28, 3 (PTAB Mar. 22, 2024)	92
<i>fubotv Media Inc. v. Dish Techs. L.L.C.</i> , IPR2024-00919, Paper 14, 27-28 (PTAB Nov. 21, 2024)	90
<i>General Plastic Industrial Co., Ltd. v. Canon Kabushiki Kaisha</i> , IPR2016-01357, Paper 19, 9-10 (PTAB Sept. 6, 2017)	88, 89
<i>Luminex Int’l Co. Ltd. v. Signify Holdings B.V.</i> , IPR2024-00101, Paper 20, 9 (PAB Nov. 21, 2024)	90, 91, 93
<i>Monolithic Power Sys., Inc. v. Greenthread LLC</i> , IPR2024-00551, Paper 26, 10 (PTAB Oct. 9, 2024)	92
<i>Samsung Elecs. Co., Ltd. v. Netlist, Inc.</i> , IPR2022-00615, Paper 20, 17-18 (PTAB Oct. 19, 2022)	92
<i>Signify North America Corp. v. CAO Lighting, Inc.</i> , IPR2023-00213, Paper 16, 23-24, n.13 (PTAB Jun. 15, 2023)	94
<i>Sony Mobile Commc’ns Ab v. Ancora Techs., Inc.</i> , IPR2021-00663, Paper 17, 10-11 (PTAB June 10, 2021)	91
<i>Valve Corp. v. Elec. Scripting Prods., Inc.</i> , IPR2019-00062, Paper 11, 9-10 (PTAB Apr. 2, 2019)	89
<i>Verizon Connect Inc. v. Omega Pats., LLC</i> , IPR2023-01162, Paper 12, 16-18 (PTAB Feb. 21, 2024)	97
<i>Videndum Prod. Sols. v. Rotolight Ltd.</i> , IPR2023-01218, Paper 12, 6 (PTAB Apr. 19, 2024)	89, 90
<i>WesternGeco LLC v. ION Geophysical Corp.</i> , 889 F.3d 1308, (Fed. Cir. 2018)....	93

Statutes

35 U.S.C. §325(d)	94
-------------------------	----

Regulations

37 C.F.R. § 42.8(b)(1)	97
37 C.F.R. §§ 42.8(b)(3)	98
37 C.F.R. §42.24.....	107
37 C.F.R. §42.8.....	107

I. INTRODUCTION

IPR is requested of Claims 1-18 of USPN 11,721,714. The '714 Patent describes utilizing reflective layers of differing refractive indexes to reflect incident light on an image sensor back towards the image sensor's pixel. *'714 Patent* (Ex. 1001), 1:43–2:16. Such “sandwich” techniques for effecting desired light reflection were well-known, including use of Bragg reflectors. *Dec.*, ¶35, ¶62.¹ Even the '714 Patent admits the disclosed material “sandwich” is “designed to function as” and “forms a Bragg reflector.” *'714 Patent*, 8:35-43, 8:65–9:15. The structures and techniques of the Challenged Claims were known prior to the '714 Patent.

This Petition presents two distinct sets of grounds of unpatentability based on Hwang-099 (Grounds 1-7) and Hong (Grounds 8-14).

II. LEVEL OF SKILL OF A POSITA

For purposes of this IPR, Petitioners apply SiOnyx's POSITA level of skill, namely having “at least a bachelor's degree in electrical engineering, materials science, or physics (or an equivalent degree), at least two years of experience in optoelectronics, and at least three years of work experience in semiconductor manufacturing....[A] master's degree or Ph.D. in a relevant field may substitute for some work experience or vice versa.” (Ex. 1014, 18).

¹ “*Dec.*” citations are paragraphs of Ex. 1003, Declaration of Dr. Stanley Shanfield.

III. REQUIREMENTS UNDER 37 C.F.R. §42.104

A. Grounds for Standing Under 37 C.F.R. §42.104(a)

Petitioners certify the '714 Patent is eligible for IPR.

B. Identification of Challenge Under 37 C.F.R. §42.104(b)

Petitioners request the Challenged Claims be found unpatentable on the following grounds.²

Ground	Grounds of Unpatentability
1	Claims 1-5, 9-11 are obvious over Hwang-099 (Ex. 1004)
2	Claim 6 is obvious over Hwang-099 and Komuro (Ex. 1005)
3	Claims 7-8 are obvious over Hwang-099 and Hwang-795 (Ex. 1006)
4	Claims 12-13 are obvious over Hwang-099 and Yamashita (Ex. 1007)
5	Claims 12, 14-15, and 17 are obvious over Hwang-099 and Konno (Ex. 1008)
6	Claim 16 is obvious over Hwang-099, Konno, and Kim (Ex. 1009)
7	Claim 18 is obvious over Hwang-099, in combination with Mouli (Ex. 1010) and/or Nozaki (Ex. 1011)
8	Claims 1-5, 9-13 are obvious over Hong (Ex. 1012), Yamashita, and Hwang-584 (Ex. 1013)
9	Claim 6 is obvious over Hong, Yamashita, Hwang-584, and Komuro
10	Claims 7-8 are obvious over Hong, Yamashita, Hwang-584, and Hwang-795
11	Claim 11 is obvious over Hong, Yamashita, Hwang-584, and Mouli
12	Claims 12, 14-15, 17 are obvious over Hong, Yamashita, Hwang-584, and Konno

² All cited prior art qualifies as prior art under §102(b).

13	Claim 16 is obvious over Hong, Yamashita, Hwang-584, Konno, and Kim
14	Claim 18 is obvious over Hong, Yamashita, and Hwang-584, in combination with Mouli and/or Nozaki

C. Claim Construction Under 37 C.F.R. §42.104(b)(3)

Petitioner does not believe claim construction is necessary to apply the claims to the present prior art.³

The '714 Patent is the subject of an ITC action involving SiOnyx and Samsung. §XXI.B.2. The ITC issued an Order construing certain claim terms. (Ex. 1014).

IV. SHOWING OF ANALOGOUS, PRIOR ART

The prior art is analogous to the claimed invention of the '714 Patent. The prior art is from the same field of endeavor of the '714 Patent, namely semiconductor devices for detecting light. *'714 Patent*, 6:13-18, 6:29-31, 6:48-52, 7:64-66; *Hwang-099*, 1:14-19, 1:52-57, 9:11-14, 10:23-27, 10:31-35, 15:38-41, Figures 1-2; *Hwang-795*, [0009], [0016]; *Kim*, Abstract, [0006], [0011], [0015]; *Konno*, 1:15-22, 2:56-58, 3:44-50; *Hong*, [0001], [0006], [0017], [0047]; *Mouli*, 1:6-9, 1:43-46, 3:45-48; *Hwang-584*, [0002], [0009]; *Yamashita*, [0003], [0047], [0049], [0053]; *Nozaki*,

³ Petitioners' application of prior art to the Challenged Claims is not a waiver of any argument in litigation regarding a claim term's construction or indefiniteness.

Abstract, [0033], [0036], Figure 2; *Komuro*, Abstract, [0012], [0087], [0133]; *Dec.*, ¶28, ¶80, ¶85, ¶89, ¶93, ¶97, ¶101, ¶105, ¶110, ¶116, ¶123.

The prior art is also reasonably pertinent to at least one problem facing the '714 Patent's inventors, namely the problem of reducing electrical and/or optical cross-talk between adjacent sensor pixels and/or reducing loss of light. '714 Patent, 1:27-40, 6:13-25; *Hwang-099*, 1:55-58, 10:19-27; *Hwang-795*, Abstract, [0016]; *Kim*, [0011]; *Konno*, 5:24-25, 4:15-16, 6:2-3; *Hong*, [0001], [0026]; *Mouli*, 1:55-59, 2:49-53, 4:27-32, 6:29-33; *Hwang-584*, Abstract, [0002], [0009], [0011], [0021]; *Yamashita*, [0007], [0011], [0091]-[0093], [0115], Figures 4-6; *Nozaki*, [0018]; *Komuro*, Abstract, [0011], [0090]; *Dec.*, ¶30, ¶81, ¶86, ¶90, ¶94, ¶98, ¶102, ¶106, ¶111, ¶117, ¶124.

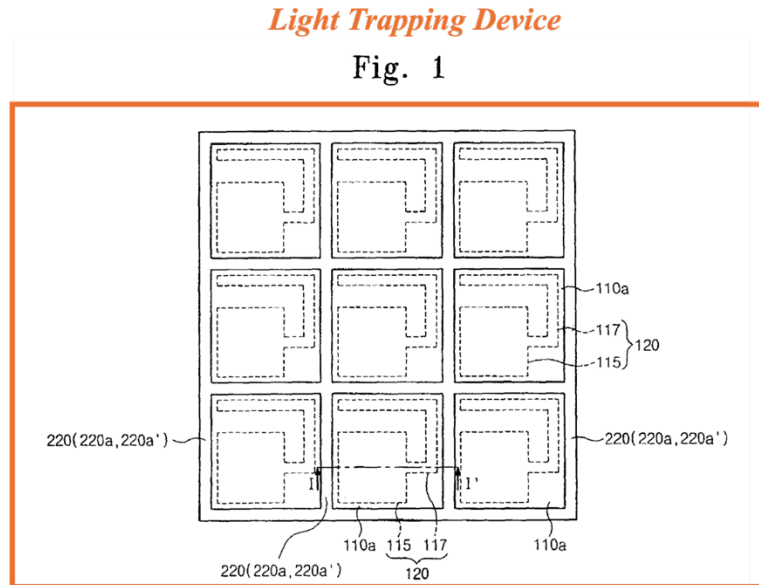
V. GROUND 1: CLAIMS 1-5, 9-11 ARE OBVIOUS OVER HWANG-099

Hwang-099's Figure 2 embodiment modified in view of Hwang-099's Figure 6 embodiment renders Claims 1-5, 9-11 obvious.

A. Claim 1

1. 1[Pre]: “A *light trapping device, comprising:*”

Hwang-099 teaches or suggests a *light trapping device*⁴, namely the image sensor shown in Figure 1:



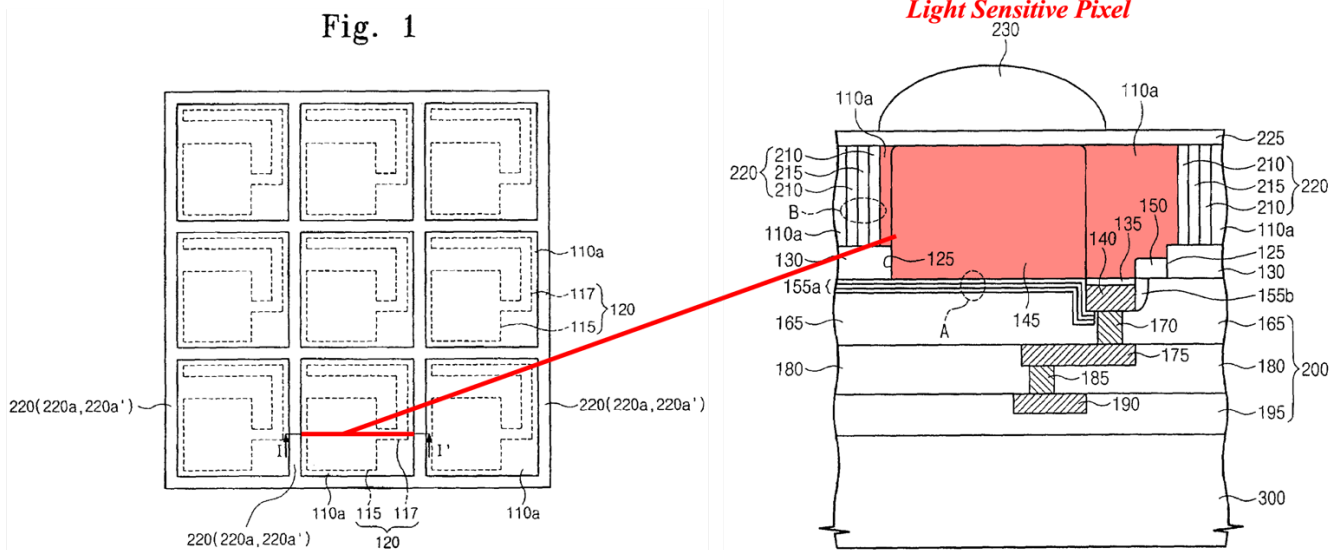
Dec., ¶126.

⁴ Claim language provided in italics. All drawing annotations added. Claim language in colored font maps to same-colored regions in the annotated drawings. Citations to a claim limitation and/or section number are to the limitation’s mapping in this Petition and are incorporated by reference, including the Motivations to Combine (MTC) and showing of reasonable expectation of success (REOS) provided in the cross-referenced section. All REOS include the benefits described for the respective MTC. All emphases added unless otherwise noted.

Hwang-099's image sensor is *light trapping* because it “minimiz[es] interference between neighboring pixels...” and/or is surrounded by sidewall multi-layered reflection layer 220 reflecting light back into the pixel. *Hwang-099*, 5:47-55, 1:55-58, 3:20-26, 10:19-35; cf. '714 Patent, 11:27-30; Dec., ¶¶127-128.

2. 1[a]: “at least one light sensitive *pixel*”

Hwang-099 teaches at least one light sensitive *pixel*, namely at least the portion comprising pixel semiconductor pattern 110a and photodiode 145 formed therein, shown in Figures 1-2:

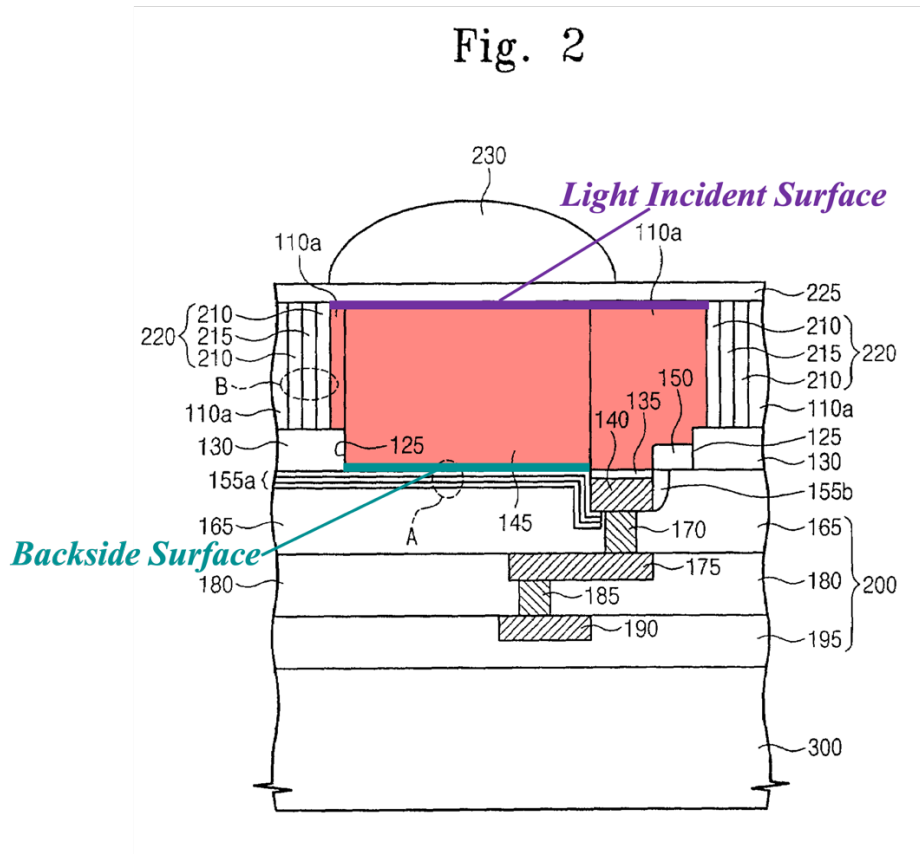


Dec., ¶129. Figure 1's image sensor comprises a plurality of pixel semiconductor patterns 110a arranged two-dimensionally in rows/columns; each pattern 110a has a photodiode 145 disposed therein. *Hwang-099*, Figures 1-2, 5:47-58. Pattern 110a and photodiode 145 are *light sensitive pixels* because they collectively allow

efficient collection of electron-hole pairs generated by absorbed light, thus converting light into an electrical signal. *Hwang-099*, 5:52–6:4, 1:23-29, 10:36-40, 1:52-54, 1:14-29; *Dec.*, ¶¶130-133.

3. *1[a][i]*: “having a *light incident surface*, a *backside surface* opposite the light incident surface”

Hwang-099’s *pixel* includes a *light incident surface* and a *backside surface*, namely portions of respective second and first surfaces of pattern 110a and photodiode 145 (collectively, the *pixel*):



Dec. ¶134; Claim 1[a], §V.A.2. The pixel semiconductor pattern 110a and photodiode 145, which is “disposed” within pattern 110a, “have first and second

surfaces in parallel, i.e., that face one another.” *Hwang-099*, 5:57-58, 6:37-38, 6:61-65. In annotated Figure 2, above, at least the portion of the first surface of 110a/145 as annotated is a bottom surface (*backside surface*) because it “is more proximate to the substrate 300[,]” and at least the portion of the second surface of 110a/145 as annotated is a top surface (*light incident surface*) because it receives incident light. *Hwang-099*, 6:38-40, 8:20-22, 9:6-7, 1:14-18; *Dec.*, ¶135. Because the top/second and bottom/first surfaces of pattern 110a “face one another” and are “parallel,” the surfaces are *opposite*. *Hwang-099*, 6:37-38; *Dec.*, ¶136. Petitioner notes Claim 1[a][i] does not include any limitations regarding a width of each surface, including widths relative to each other or other claimed elements.

4. *1[a][ii]: “a **peripheral sidewall** disposed into at least a portion of the pixel and extending at least substantially around the pixel periphery”*

Hwang-099 teaches or suggests a *peripheral sidewall*, namely a sidewall of a trench formed in pixel semiconductor pattern 110a:

Fig. 1

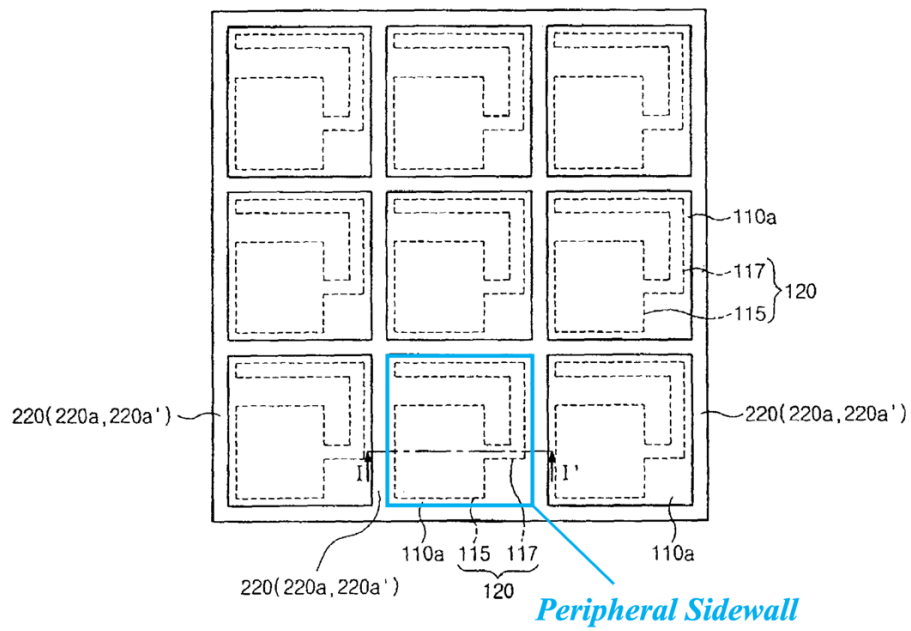
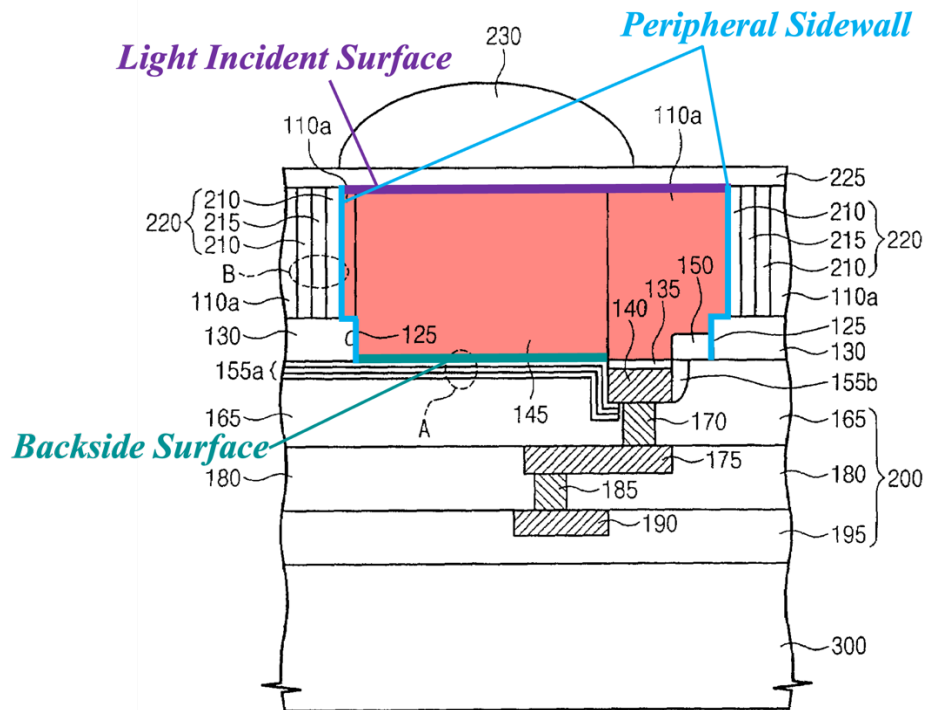
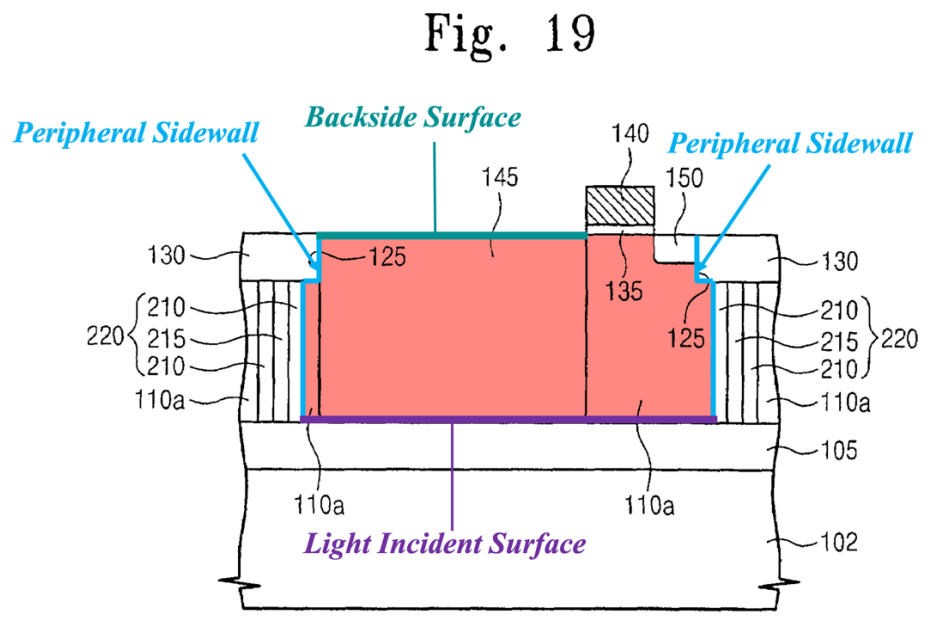
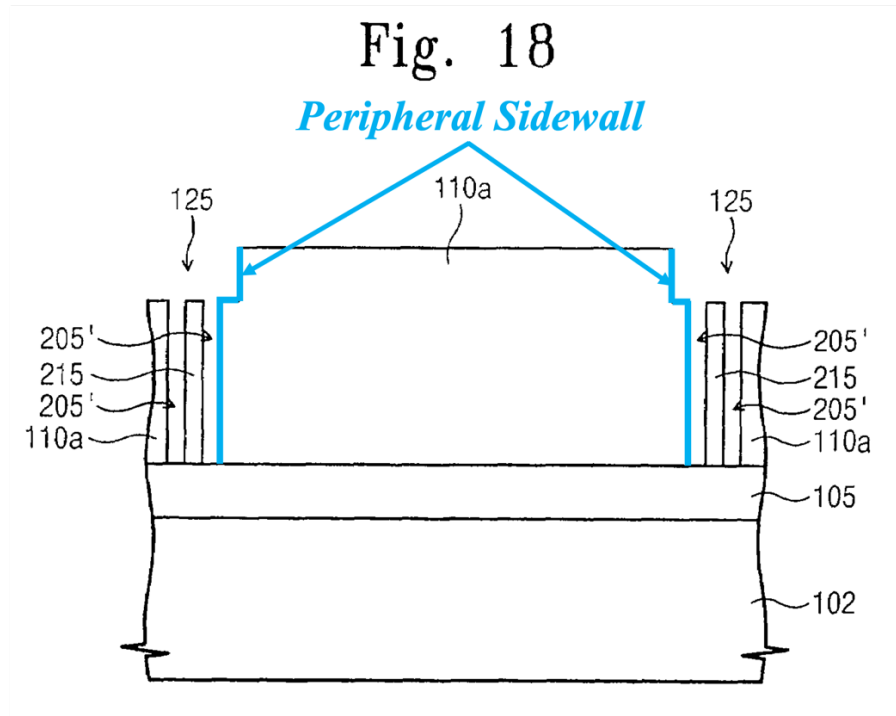


Fig. 2



Dec., ¶¶137-139.

Hwang-099 teaches forming a trench by etching pixel semiconductor layer/pattern 110a, where sidewall of trench formed in layer 110a is a *peripheral sidewall*. Cf. '714 Patent, 11:21-22; Ex. 1014, 20 (providing ITC's construction of agreed-upon terms, including "sidewall" as "Plain and ordinary meaning. To the extent a construction is required: trench wall"). Figures 18-19 describe an "alternate embodiment of a method of forming" the Figure 2 image sensor. *Hwang-099*, 13:64–14:22; *Dec.*, ¶¶74-77, ¶138. "[S]emiconductor layer 110 is patterned to form a trench 125[,]" and then "the floor of the trench 125 is selectively etched to form a plurality of grooves 205" that "encloses one pixel semiconductor pattern 110a in layers." *Hwang-099*, 14:3-12. Thus, semiconductor pattern 110a material is removed from semiconductor layer/pattern 110a to form a sidewall via etching trench 125 and grooves 205:



Dec., ¶¶139-141.

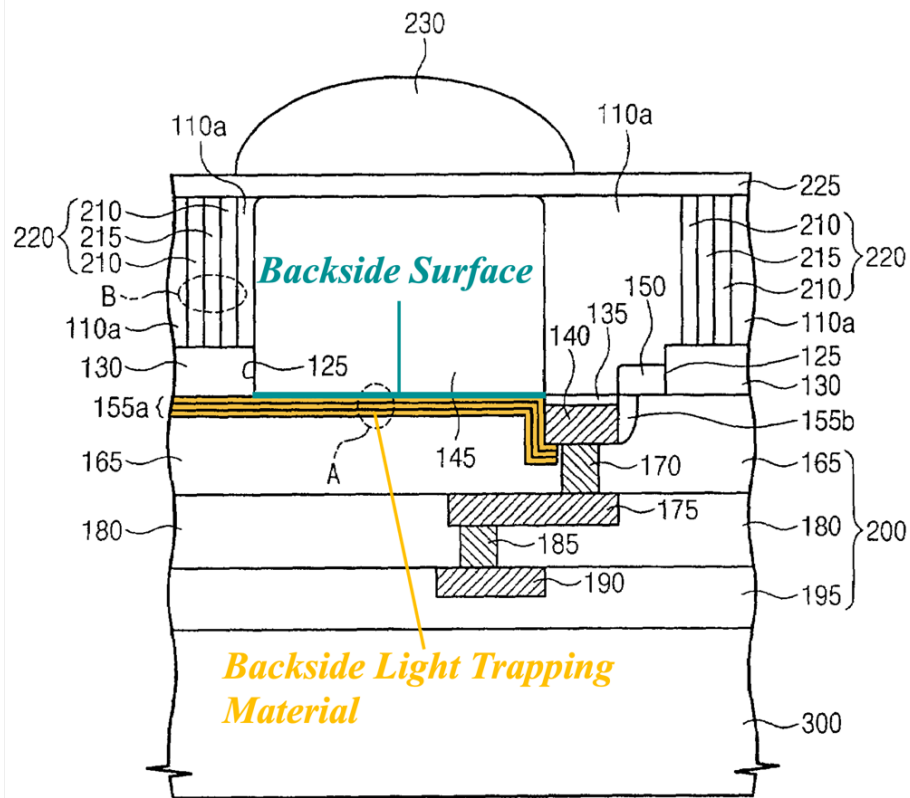
Hwang-099’s “sidewall of the pixel semiconductor pattern 110a” is *disposed into at least a portion of the pixel* because the semiconductor layer/pattern 110a (part

of *pixel* (§V.A.2)), is etched to form trench 125 and grooves 205. *Hwang-099*, 14:20-22, 5:52-57; *Dec.*, ¶142. *Hwang-099*'s pattern 110a sidewall *extend[s] at least substantially around the pixel periphery* because grooves 205 “surround[] the pixel semiconductor patterns 110a” and are “formed between a pair of neighboring pixel semiconductor patterns 110a[,]” per Figure 1. *Hwang-099*, 12:42-53, 3:60-67; *Dec.*, ¶143. Additionally, in Figure 1's plan view, the sidewall of pattern 110a (*peripheral sidewall*) extends completely around the pixel periphery because there are no gaps in the sidewall as it surrounds the pixel periphery. *Dec.*, ¶144.

5. *1[b]: “a backside light trapping material at least partially covering the backside surface”*

Hwang-099 teaches or suggests a *backside light trapping material*, namely base multi-layered reflection layer 155a, “contact[ing] the first surface of the pixel semiconductor pattern 110a” (*backside surface*):

Fig. 2



Dec., ¶148; Hwang-099, 7:45-47; Claim 1[a][i], §V.A.3.

“The base multi-layered reflection layer 155a includes at least two stacked layers having different refractive indexes[,]” such as “first base multi layered reflection layer 151 and a second base multi-layered reflection layer 152.” Hwang-099, 8:32-44. Because layer 155a extends across substantially the entire portion of the *backside surface* in annotated Figure 2, layer 155a (*backside light trapping material*) at least partially cover[s] the *backside surface*. Dec., ¶149.

Layer 155a is *light trapping* because “external light incident on the second surface of the photodiode 145 is reflected by” a “boundary surface” within “the base multi-layered reflection layer 155a” to be “incident again on the photodiode 145.” *Hwang-099*, 9:6-11; *Dec.*, ¶¶145-147.

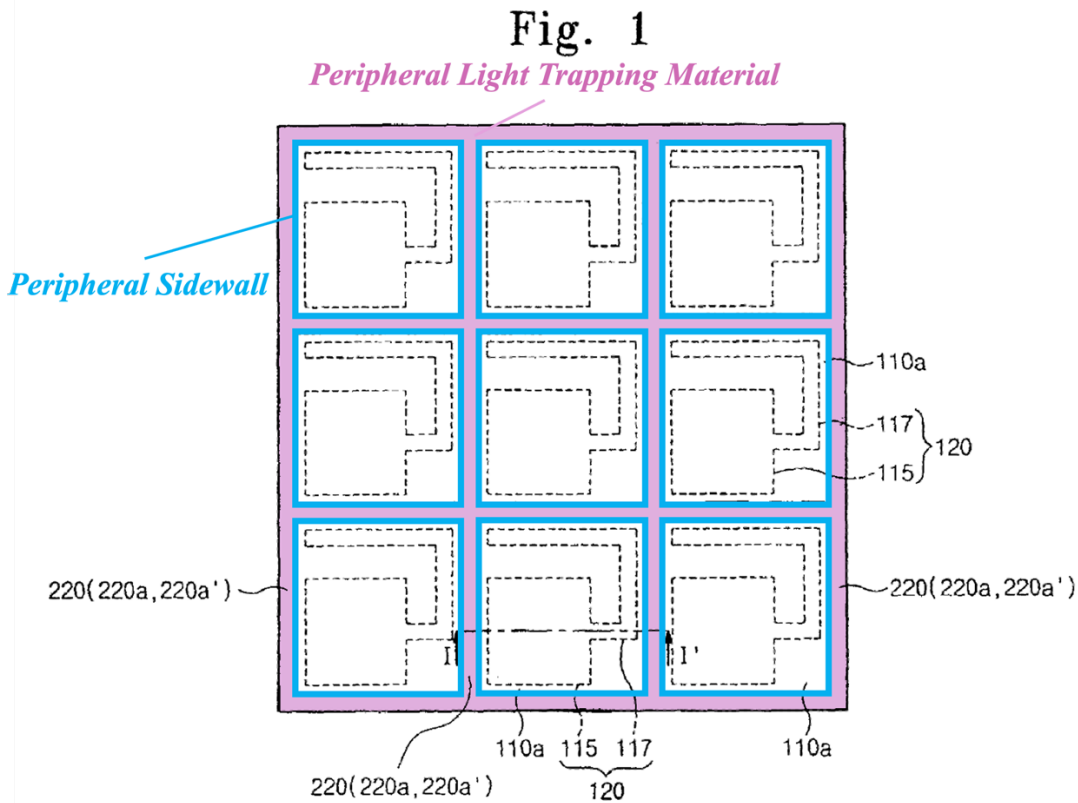
6. 1[c]: “a *peripheral light trapping material* substantially covering the *peripheral sidewall*”

Claim 1[c]’s mapping modifies Hwang-099’s Figure 2 embodiment with Hwang-099’s Figure 6 embodiment, namely layer 220 extending into peripheral isolation element 130. The *peripheral light trapping material* is met by Hwang-099’s layer 220 modified per Figure 6 to *substantially cover the peripheral sidewall*, where the collective sidewall multi-layered reflection layer 220 and modified device isolation pattern 130 meet Claim 1[c].

a) Hwang-099’s Teachings

Hwang-099 teaches a “[s]idewall multi-layered reflection layer 220 [that] encloses the side walls of the pixel semiconductor patterns 110a.” *Hwang-099*, 6:15-23 (further disclosing layer 220 separating patterns 110a and “disposed along the boundaries” of the patterns), 6:32-36, 3:63-67, Figure 1.

Because layer 220 “encloses” pattern 110a’s *sidewall*, a POSITA would have understood layer 220 is *peripheral*:



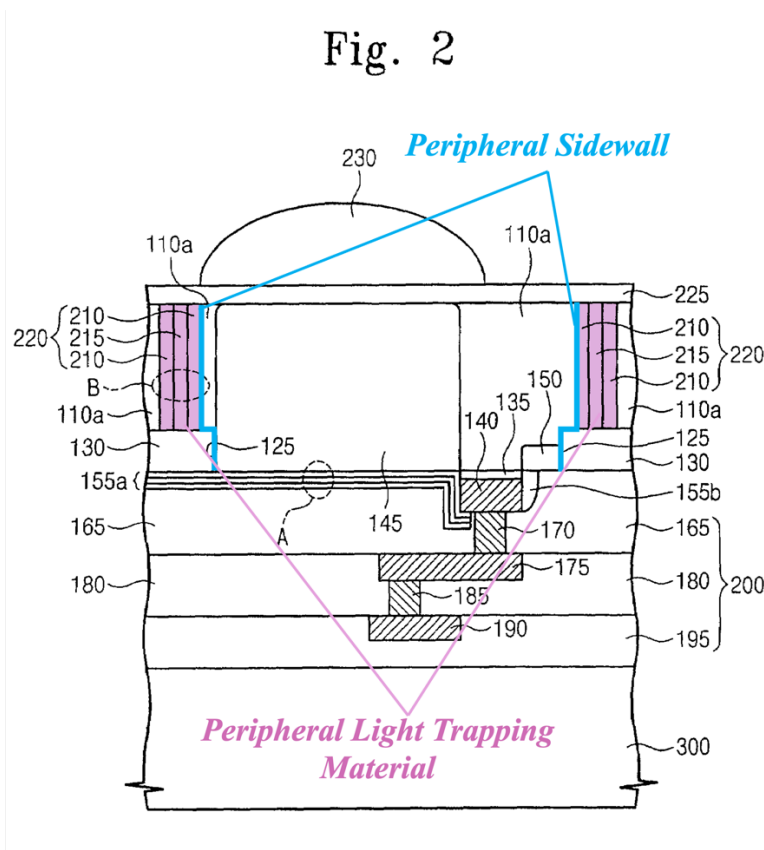
Dec., ¶¶153-154.

Reflection layer 220 “includes layers with different respective refractive indexes.” *Hwang-099*, 9:52-53. Layer 220 “includes a first sidewall reflection layer 210 and a second sidewall reflection layer 215” where “[t]he refractive index of the first sidewall reflection layer 210 is different from the refractive indexes of the pixel semiconductor pattern 110a and the second sidewall reflection layer 215.” *Hwang-099*, 9:58-63. “[T]he portion of the light reflected toward the sidewall multi-layered reflection layer 220 from the light reflected by the first and second boundary surfaces is incident again on the photodiode 145 so that absorption efficiency of external light is increased.” *Hwang-099*, 10:31-35. Thus, layer 220 is *light trapping* because it

reflects light incident on the boundary surfaces of layer 220 onto photodiode 145.

Dec., ¶¶151-153.

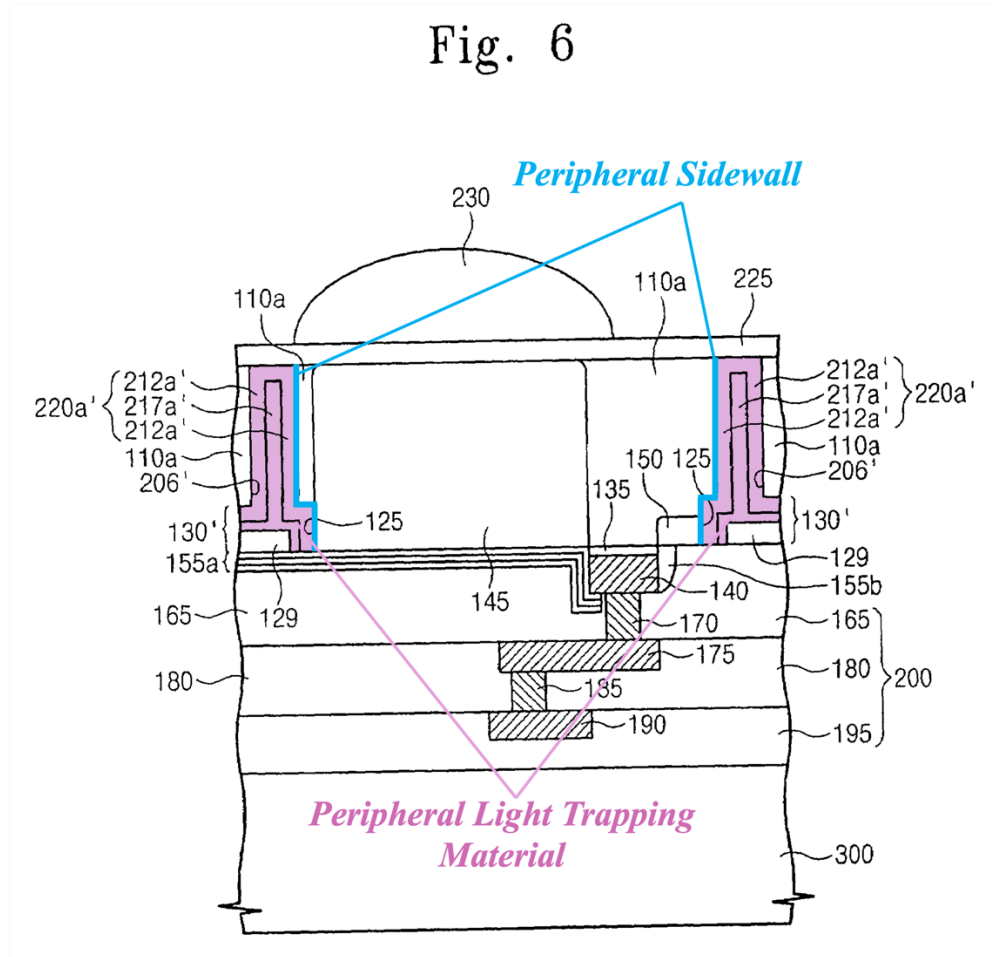
In the Figure 2 embodiment, below, layer 220 is a *peripheral light trapping material* covering part of pattern 110a's sidewall (*peripheral sidewall*), while isolation element 130 covers the remaining portion of the sidewall:



Dec., ¶155.

In the Figure 6 embodiment, Hwang-099 teaches device isolation pattern 130' “include[s] **extended portions of the first and second sidewall reflection layers 212a' and 217a'.**” *Hwang-099*, 12:26-28, Figure 6. The first and second sidewall reflection layers extend through the isolation pattern 130' to base multi-layered

reflection layer 155a, where the *sidewall* is *substantially covered* by *peripheral light trapping material* 220a':



Dec., ¶156.

b) Motivation to Combine

A POSITA would have found it obvious and been motivated to modify Figure 2's device isolation pattern 130 such that first and second layers 210, 215 of reflection layer 220 extend through pattern 130 to *substantially* and completely cover pattern 110a's sidewall, per the Figure 6 embodiment. Dec., ¶157 (citing *Hwang-099*, 1:31-47). The modification would have given device isolation pattern

130 the same *light trapping* ability as layer 220 due to the difference in refractive indexes between the first and second layers 210, 215. *Dec.*, ¶158. A POSITA would have understood increasing the surface area of the light-trapping material on the peripheral sidewall would predictably increase the amount of light reflected back into the pixel, thereby providing the benefit of increasing the number of photons returned to the photodiode. *Dec.*, ¶159. There would have been a REOS at least because Hwang-099 provides methods for manufacturing an isolation pattern 130' having first and second sidewall reflection layers. *Hwang-099*, 14:3-22, 12:35–13:3; *Dec.*, ¶160.

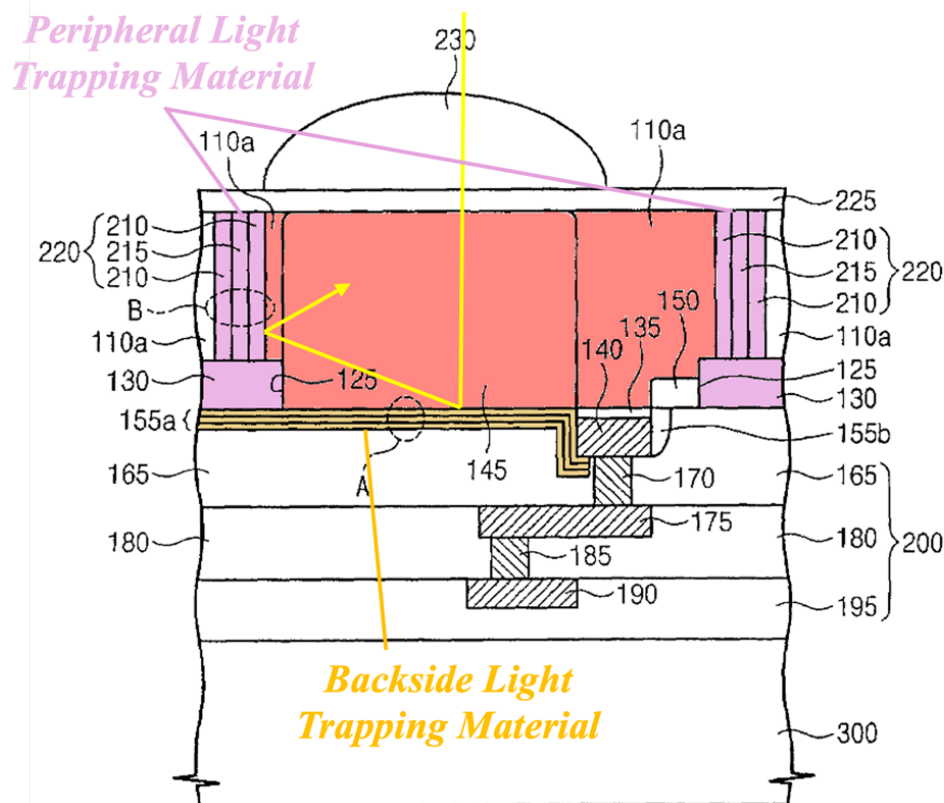
7. ***1[d]: “wherein light contacting the backside light trapping material or the peripheral light trapping material is reflected back toward the pixel”***

Hwang-099's base multi-layered reflection layer 155 (*backside light trapping material*) reflects light back toward the *pixel*. Claim 1[b], §V.A.5. Reflection layer 155a “has at least two layers with different refractive indexes[.]” where layer 155a has at least one “boundary surface reflecting light[.]” *Hwang-099*, 8:64–9:14. “[E]xternal light incident on the second surface of the photodiode 145” is “reflected by” at least the layer 155a's boundary surface and another boundary surface and “is incident again on the photodiode 145.” *Hwang-099*, 9:6-14. Thus, Hwang-099 expressly teaches *light contacting* reflection layer 155 (*backside light trapping*

material) is reflected back toward the *pixel*, namely photodiode 145 forming part of *pixel*. Dec., ¶¶162-163.

Similarly, Hwang-099’s reflection layer 220 (*peripheral light trapping material*) reflects light back toward the *pixel*. Claim 1[c], §V.A.6. In layer 220, light “reflected from the first and second boundary surfaces” is “reflected by the third boundary surface” and the “fourth boundary surface” and “is incident again on the photodiode 145[.]” *Hwang-099*, 10:28-40.

Fig. 2



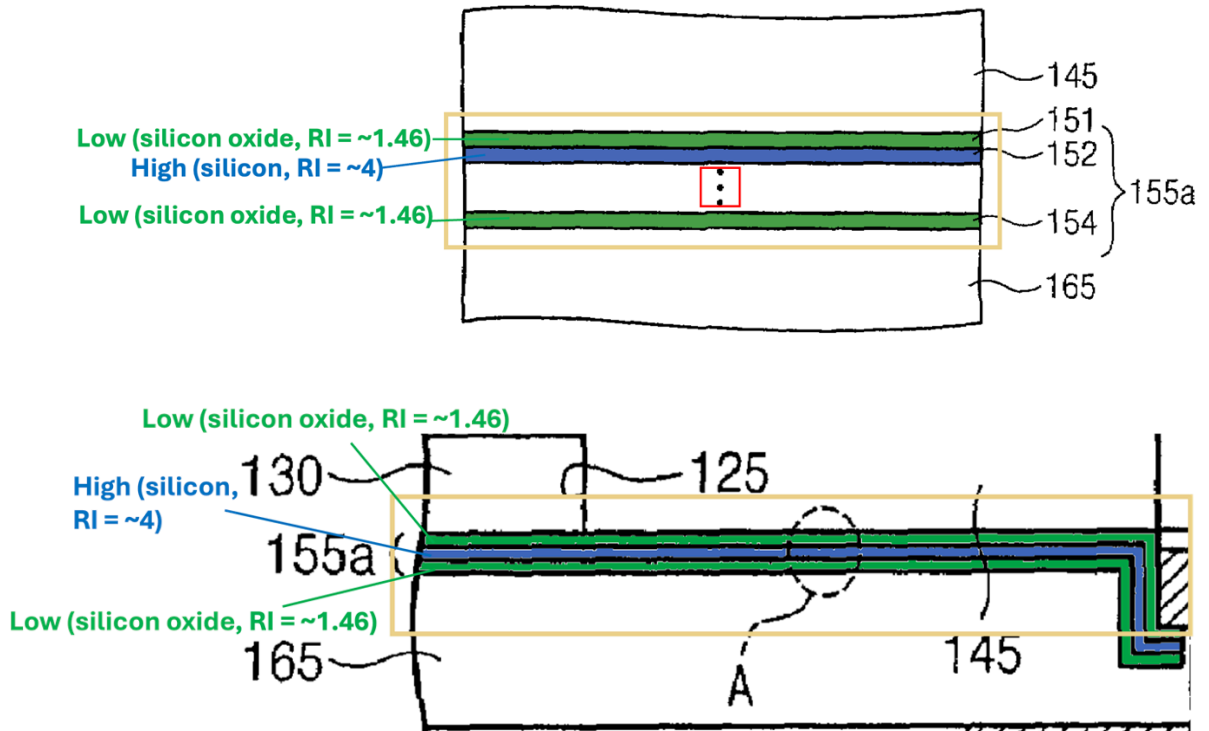
Dec., ¶¶164-165.

8. *1[e]: “wherein at least one of the **backside light trapping material** or the **peripheral light trapping material** includes a **high refractive index material** sandwiched between **two low refractive index materials**.”*

a) *Backside Light Trapping Material*

Hwang-099’s base multi-layered reflection layer 155a (**backside light trapping material**) includes a **high refractive index material** sandwiched between **two low refractive index materials** (hereinafter “low-high-low sandwich”). *Dec.*, ¶¶167-169. Layer 155a includes “a first base multi-layered reflection layer 151 and a second base multi-layered reflection layer 152” having different refractive indexes. *Hwang-099*, 8:40-44. Layer 155a further includes layer 154 contacting the “interlayer insulating layer 200.” *Hwang-099*, 8:57-58, Figure 3. Hwang-099 teaches stacking layers 151, 152 three times. *Hwang-099*, 9:25-26. “[T]he first and second base multi-layered reflection layers 151 and 152 [are] respectively formed of silicon oxide (with a refractive index of approximately 1.46) and silicon (with a refractive index of approximately 4)[.]” *Hwang-099*, 9:25-34. Therefore, second base multi-layered reflection layer 152 has a higher refractive index than Hwang-099’s first base multi-layered reflection layer 151. *Dec.*, ¶170.

Fig. 3



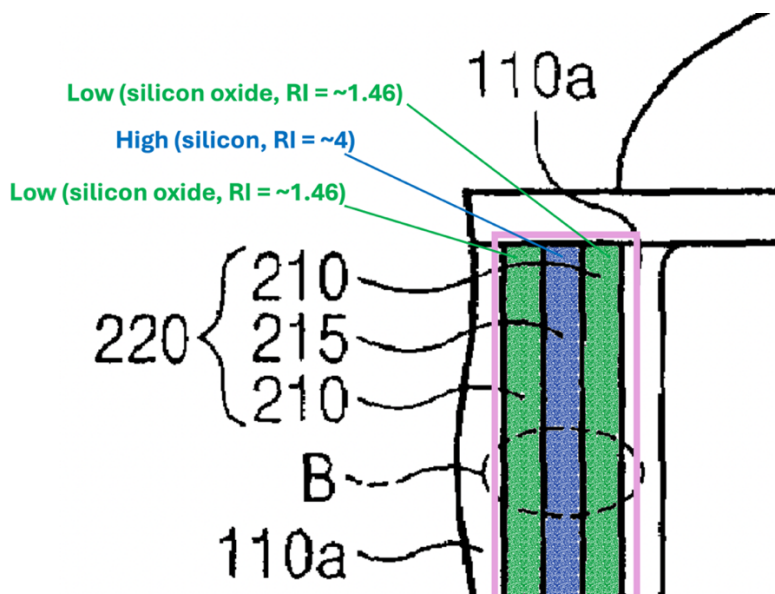
Dec., ¶170.

Because layers 151, 152 may be stacked three times, the stacked layers satisfy Claim 1[e]’s recited low-high-low sandwich. *Dec.*, ¶¶169-170. Because “layer 154” may be the “first base multi-layered reflection layer 151 or the second base multi-layered reflection layer 152[,]” when there are 3 layers total, the base multi-layered reflection layer 155 (*backside light trapping material*) stacked with layers 151, 152 also satisfies Claim 1[e]. *Hwang-099*, 8:57-60; *Dec.*, ¶170.

b) Peripheral Light Trapping Material

Hwang-099's layer 220 (*peripheral light trapping material*) also satisfies Claim 1[e]'s low-high-low sandwich. *Dec.*, ¶¶171-175.

Hwang-099 teaches layer 220 “having a second sidewall reflection layer 215 interposed between two first sidewall reflection layers 210[,]” where layers 210, 215 are “respectively formed of a silicon oxide layer and a silicon layer[.]” *Hwang-099*, 10:48-55. Layer 210's refractive index is lower than layer 215's refractive index, thus forming Claim 1[e]'s low-high-low sandwich comprising layers 210/215/210. *Hwang-099*, 9:58-66.

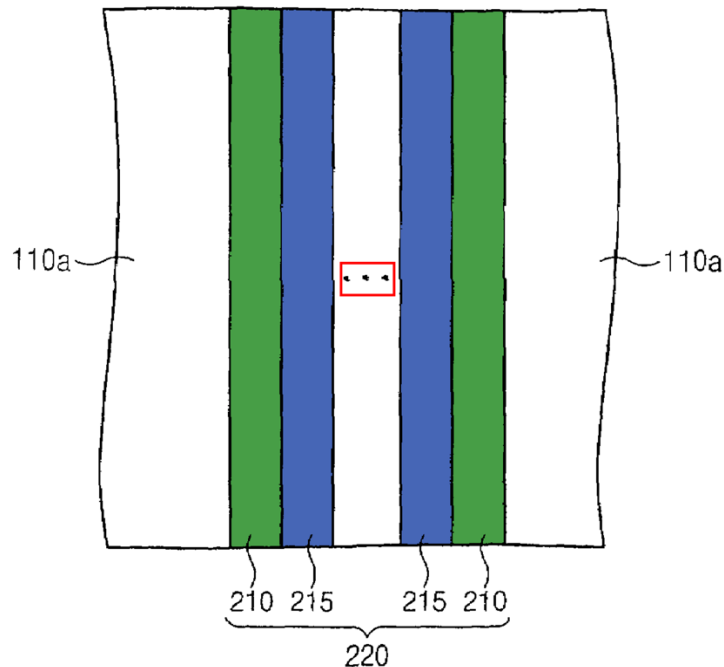


Dec., ¶172.

Layers 210/215 may be “stacked in an alternating manner a plurality of times[,]” and “both the layers of the sidewall multi-layered reflection layer 220

contacting the pair of neighboring pixel semiconductor patterns 110 can be the first sidewall reflection layer 210.” *Hwang-099*, 10:6-17.

Fig. 4



Dec., ¶173.

B. Claim 2

Hwangs-099's two low refractive index materials in both the peripheral and backside light trapping materials are silicon oxide, having a refractive index of 1.46, less than about 2.1. Claim 1[e], §V.A.8; Dec., ¶176.

C. Claim 3

Hwangs-099's two low refractive index materials is silicon oxide, a member of the claimed group oxide. Dec., ¶177; Claim 1[e], §V.A.8.

D. Claim 4

Hwangs-099's *two low refractive index materials* are silicon oxide, a *member* of the claimed group *silicon oxide*. Dec., ¶178; Claim 1[e], §V.A.8.

E. Claim 5

Hwangs-099's *high refractive index material* is silicon, having a refractive index of approximately 4, which is *greater than or equal to about 2.1*. Dec., ¶179; Claim 1[e], §V.A.8.

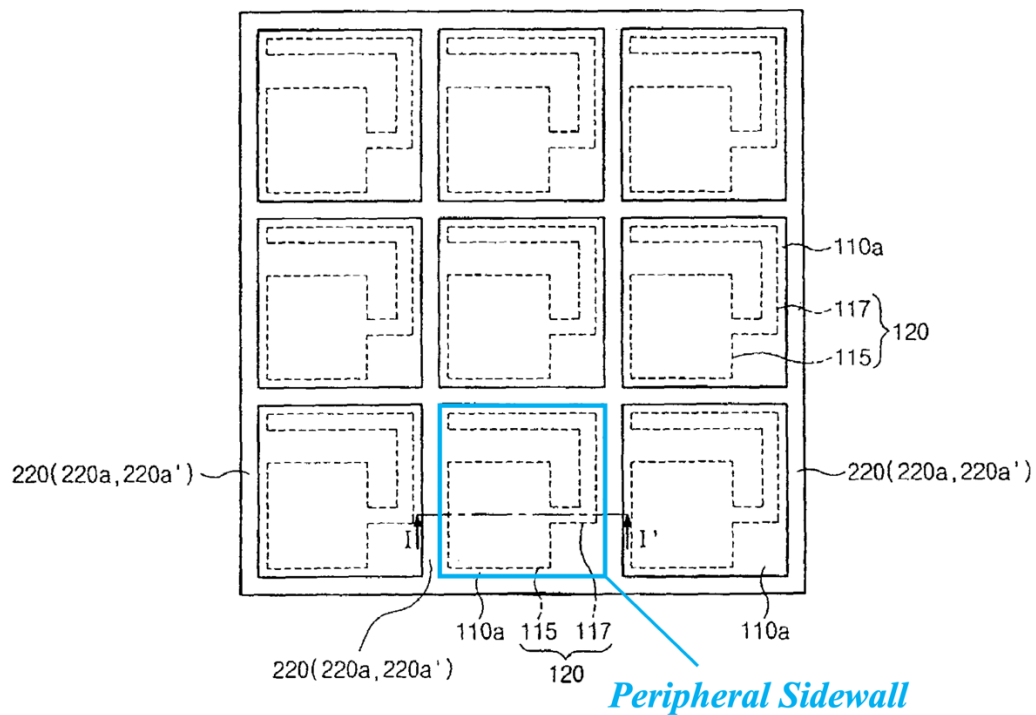
F. Claim 9

See Claim 1[e], §V.A.8. The first material (*high refractive index material*) is silicon with refractive index of approximately 4; the second material (*two low refractive index materials*) is silicon oxide with refractive index of approximately 1.46. Hwang-099, 9:25-34, 10:48-55; Dec., ¶¶180-182; cf. '714 Patent, 10:35-38 (describing the two low refractive index materials may be the same or different materials). The *difference in refractive index* is approximately 2.54, which is *at least 0.2*.

G. Claim 10

Hwang-099 teaches the *peripheral sidewall* extends completely around the *pixel periphery*, such that there are no gaps in the sidewall as it encloses the pixel:

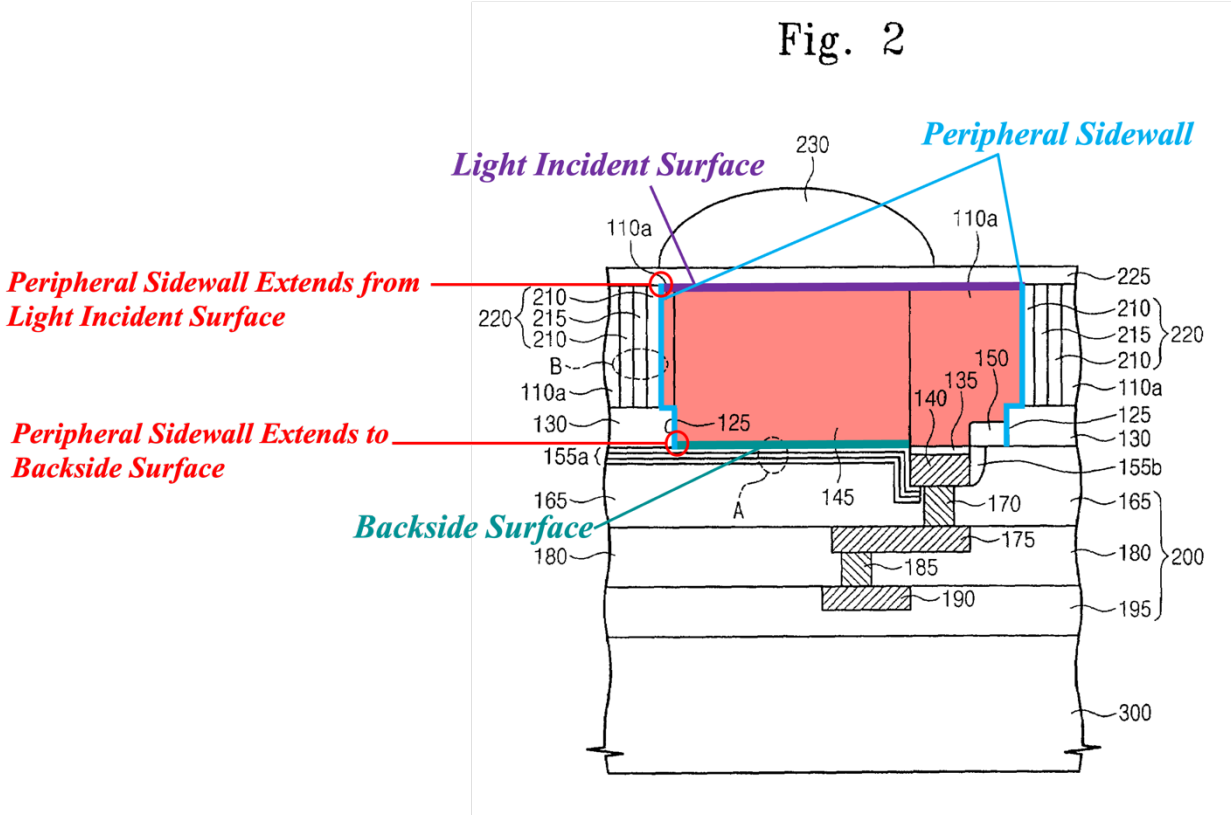
Fig. 1



Dec., ¶183; Claim 1[a][ii], §V.A.4.

H. Claim 11

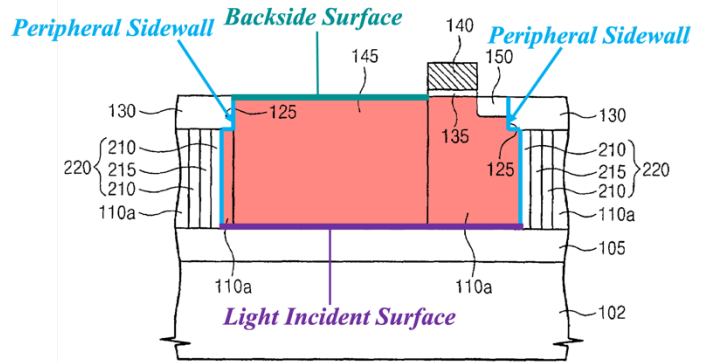
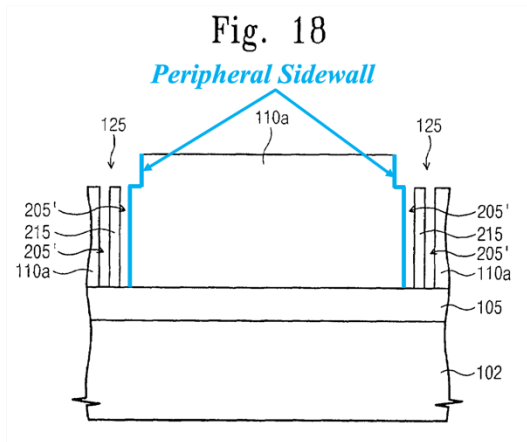
Hwang-099 teaches or suggests the *peripheral sidewall* extends from the *light incident surface* to the *backside surface*:



Dec., ¶184; Claim 1[a][i]-[ii], §§V.A.3-4.

Additionally, etching of trench 125 and grooves 205 that forms the *peripheral sidewall* includes etching to a portion of the second surface of the semiconductor pattern 110a (*light incident surface*). Claim 1[a][ii], §V.A.4; *Dec.*, ¶185. Similarly, pattern 110a is etched through a portion of the first surface (*backside surface*). *Id.*

Fig. 19



Therefore, the forming method of Hwang-099's Figures 18-19 further confirms the peripheral sidewall extends from the *light incident surface* to the *backside surface*. Dec., ¶186.

VI. GROUND 2: CLAIM 6 IS OBVIOUS OVER HWANG-099 AND KOMURO

A. Hwang-099’s Teachings

Hwang-099’s *high refractive index material* is silicon with a refractive index of “approximately 4” at a “long red-colored wavelength.” *Hwang-099*, 9:29-33; Claim 1[e], §V.A.8; *Dec.*, ¶187.

B. Komuro's Teachings

Komuro teaches silicon, including “single crystal silicon, amorphous silicon, and polysilicon” have a refractive index of 3.85 at the wavelength of red light. *Komuro*, [0137]-[0138].

TABLE 1

	Refractive Index (n)			Extinction Coefficient (k)		
	Blue Light 450 nm	Green Light 550 nm	Red Light 650 nm	Blue Light 450 nm	Green Light 550 nm	Red Light 650 nm
Germanium	4.5	6.0	5.5	2.3	2.1	1
Silicon	4.69	4.08	3.85	0.151	0.03	0.017
Tungsten	3.31	3.48	3.76	2.47	2.72	2.95
Plasma Silicon Nitride	2.07	2.04	2.01	0.004	0	0.002
Aluminum	0.618	0.958	1.47	5.47	6.69	7.79
Copper	1.17	0.9	0.21	2.39	2.6	3.67
Reference: Silicon Dioxide	1.45	1.45	1.45	0.00	0.00	0.00

Komura, Table 1.

Hwang-099 combined with Komura teaches or suggests a *high refractive index material* (silicon) that *includes a member selected from...polycrystalline silicon, amorphous silicon, single crystal silicon*. Polysilicon is known as polycrystalline silicon. *Dec.*, ¶189.

C. Motivation to Combine

A POSITA would have found obvious and been motivated to implement Hwang-099's silicon (*high refractive index material*) as “any one of single crystal silicon, amorphous silicon, and polysilicon” because each possesses a refractive index of 3.85 (i.e., approximately 4 per Hwang-099's refractive index for silicon). *Hwang-099*, 9:29-33; Claim 1[e], §V.A.8; *Dec.*, ¶190. The combination would have

a REOS at least because each of single crystal silicon, amorphous silicon, and polysilicon were well-known for use in fabricating image sensors. *Dec.*, ¶191.

VII. GROUND 3: CLAIMS 7-8 ARE OBVIOUS OVER HWANG-099 AND HWANG-795

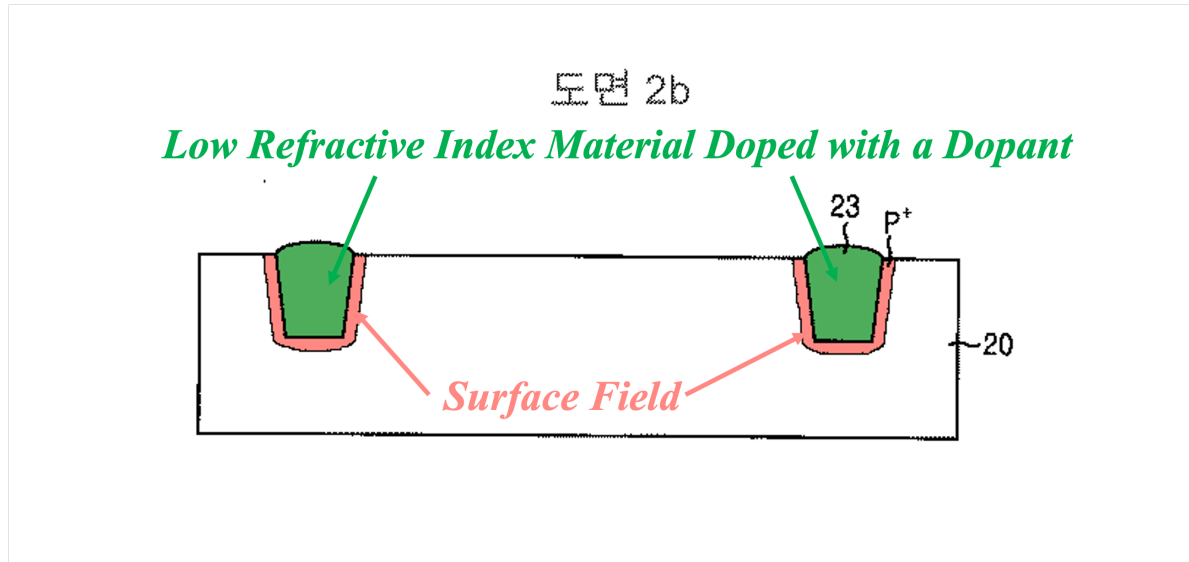
A. Claim 7

1. *Hwang-795's Teachings*

Hwang-099 combined with Hwang-795 renders obvious Claim 7. Hwang-795 teaches borosilicate glass (BSG), which is silicon dioxide doped with boron. *Dec.*, ¶¶192-195.

Hwang-795 teaches an “image sensor that can prevent crosstalk[.]” *Hwang-795*, Abstract. A trench is formed in a “semiconductor layer” through “etching.” *Hwang-795*, [0017]. A “substance doped with P-type impurity, for example BSG (borosilicate glass), or the like, is deposited, thereby burying the trench.” *Hwang-795*, [0027].

A POSITA would have understood Hwang-099's silicon oxide is silicon dioxide (*low refractive index material*). *Dec.*, ¶195; Claim 1[e], §V.A.8. In the combination, Hwang-099's silicon dioxide is doped with boron (*is doped with a dopant*), per Hwang-795's BSG deposited in trench. *Dec.*, ¶196.



Dec., ¶194.

After the trench is filled with BSG, a “simple heat process is carried out, thereby diffusing the doped P-type impurity inside the field insulation film (23)” to “form the channel stop region (P+)[.]” *Hwang-795*, [0028]. A POSITA would have understood or found obvious Hwang-795’s channel stop region (P+) creates a *surface field*. Dec., ¶193.

2. Motivation to Combine

A POSITA would have found obvious and been motivated to dope Hwang-099’s layers 210 in sidewall multi-layered reflection layer 220 with boron, per Hwang-795, to *create a surface field* and “significantly improve the performance of the image sensor.” *Hwang-795*, [0036]; Dec., ¶196. Hwang-795 expressly motivates including boron in Hwang-099’s reflection layer 210 “to reduce intermixing and crosstalk between image data and unit pixels, through more precise isolation

between unit pixels.” *Hwang-795*, [0015]. *Dec.*, ¶197. Including a dopant such as boron would improve a pixel’s “charge transfer efficiency” and “minimize dark...current[.]” *Hwang-795*, [0029]-[0030], [0036]; *Dec.*, ¶¶197-199. A POSITA would have recognized the resultant formation of the “channel stop region” after heating layers 210 in *Hwang-099*’s image sensor would have further decreased electrical crosstalk and “increase[d] the photosensitivity” of the image sensor. *Hwang-795*, [0009], [0017]-[0018], [0028]; *Dec.*, ¶¶197-199.

The modification uses a known technique (depositing borosilicate glass (i.e., boron doped silicon dioxide) in a trench), to improve similar pixels in the same way (*Hwang-099*’s image sensor’s performance is improved similar to *Hwang-795*’s image sensor (e.g., decreased electrical crosstalk and improved photosensitivity for better pixel performance in converting light into electrical signals)). *Dec.*, ¶¶198-199.

The modification would have a REOS given techniques for doping and/or depositing borosilicate glass were well-known, and a POSITA would have merely needed to dope *Hwang-099*’s silicon dioxide layers 210 with boron such that grooves 205 are filled with BSG instead of undoped silicon dioxide. *Dec.*, ¶200.

B. Claim 8

See Claim 7, §VII.A (including MTC/REOS incorporated herein), wherein the dopant is boron.

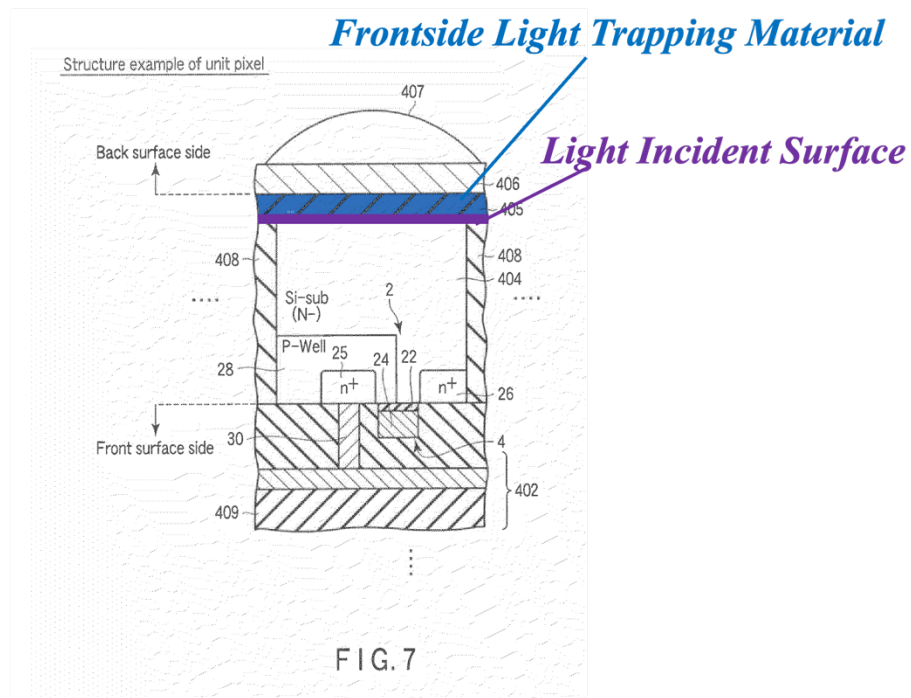
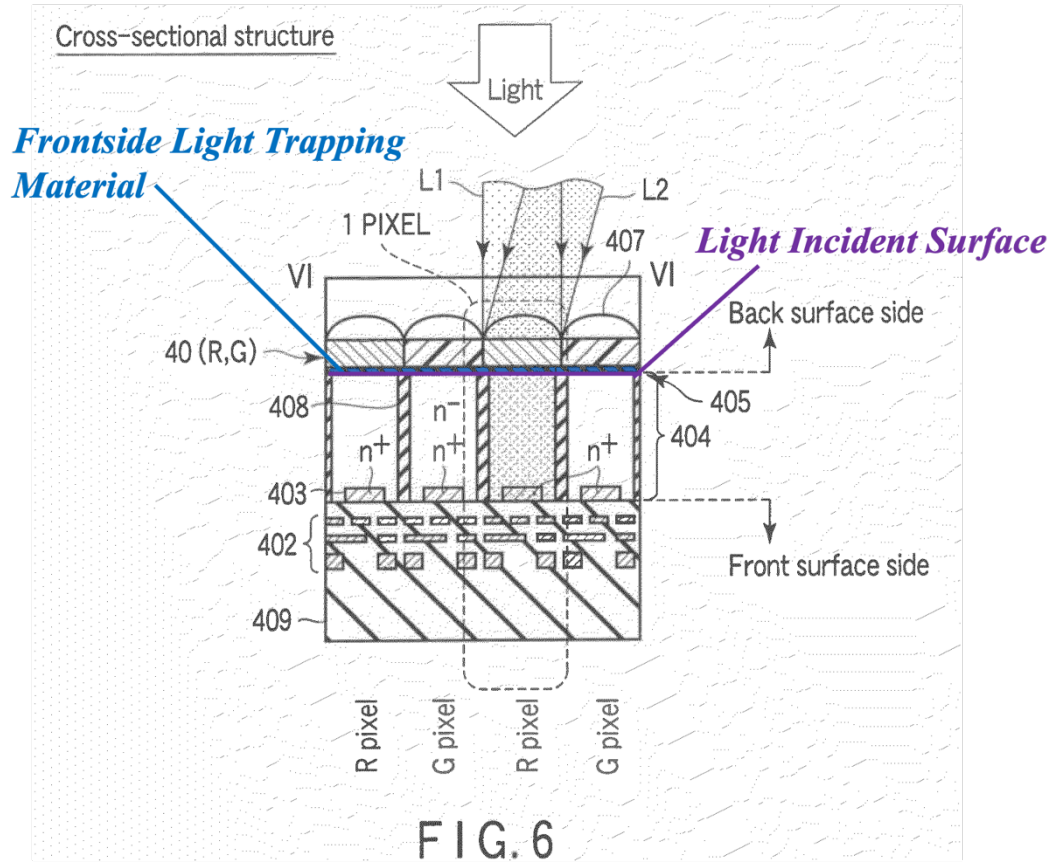
VIII. GROUND 4: CLAIMS 12-13 ARE OBVIOUS OVER HWANG-099 AND YAMASHITA

A. Claim 12

1. Yamashita's Teachings

Yamashita teaches a *frontside light trapping material*, namely “antireflection film 405” covering an entire *light incident surface*. Yamashita, [0084], [0105]-[0106] (disclosing film 405 formed on “substrate 404, which becomes the light-receiving side”), Figures 6-7, 16 (illustrating film 405 *at least partially covering* Yamashita’s light incident surface).

Yamashita’s film 405 is *light trapping* because the film is “antireflective” to prevent light from reflecting off the light incident surface (and thereby failing to be received within the pixel). Dec., ¶205. Additionally, Claim 13 defines an antireflective layer coating as light trapping; consequently, Yamashita’s “antireflective layer coating” would similarly be understood as *light trapping*.



Dec., ¶203.

2. *Motivation to Combine*

A POSITA would have found obvious and been motivated to cover Hwang-099's *light incident surface* with Yamashita's antireflection film. *Dec.*, ¶¶206-207. Antireflection films were a well-known and standard feature of image sensors before the '714 Patent. *Dec.*, ¶206. A POSITA would have known a portion of light incident on a silicon substrate is reflected away, which reduces the collection efficiency of image sensors. *Id.* A POSITA would have recognized Hwang-099's image sensor was susceptible to this issue and been motivated to mitigate it by adding an antireflection film per Yamashita's teachings to yield the predictable result of trapping light by reducing the amount of the light reflected away. *Dec.*, ¶207. Such a combination is an application of a known technique (using antireflection films) to improve similar image sensors in the same way. *Id.*

There would be a REOS, at least because antireflective films were a standard feature of image sensors, methods of applying them were well-understood, and Yamashita expressly teaches forming methods for adding an antireflection layer. *Dec.*, ¶208, ¶¶67-69; *Yamashita*, [0105]-[0113], Figures 6-7, 16.

B. **Claim 13**

See Claim 12, §VIII.A. Yamashita's *frontside light trapping material* ("antireflection film 405") is an *antireflective layer coating*.

IX. GROUND 5: CLAIMS 12, 14-15, 17 ARE OBVIOUS OVER HWANG-099 AND KONNO

A. Claim 12

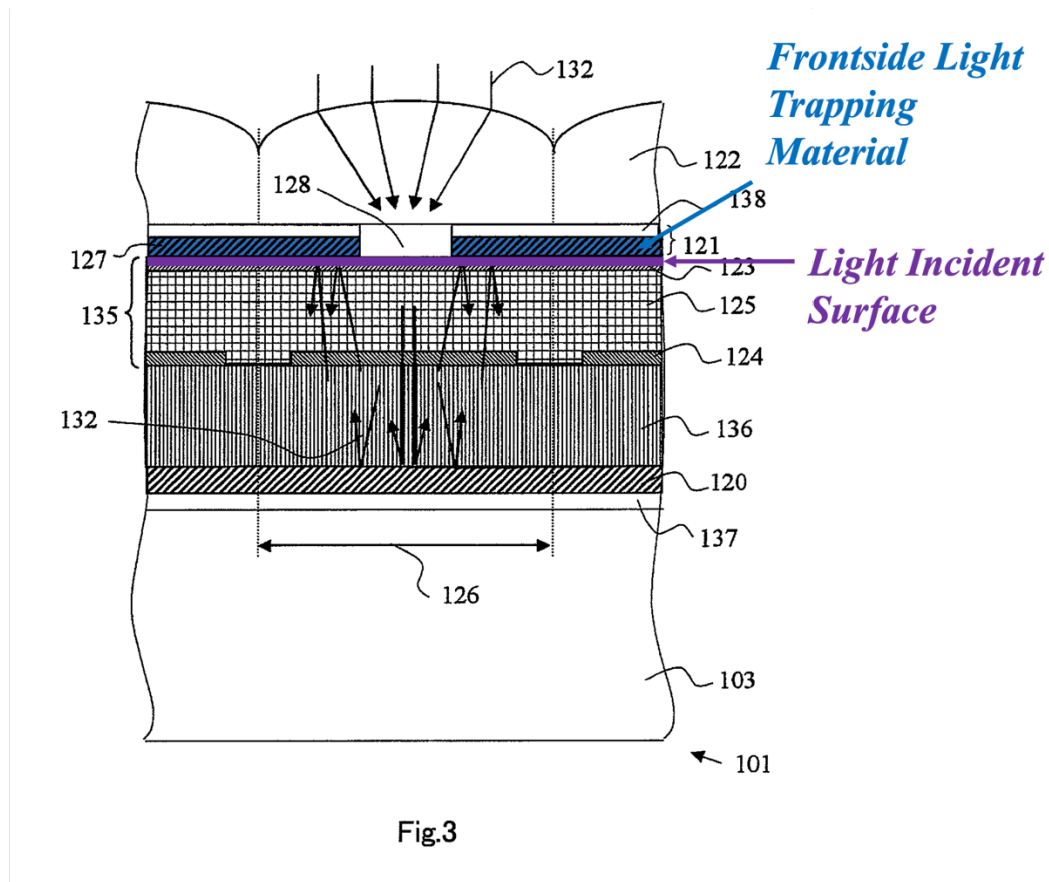
Hwang-099-Konno teach or suggest Claim 12.

1. Konno's Teachings

Konno teaches a *frontside light trapping material*, namely first reflecting layer 121, “which reflect[s] incident photons” and is located “**on the photon incidence side[.]**” *Konno*, 2:57-58, 3:10-13, 8:12-26, 8:31-38, Figure 3; *Dec.*, ¶¶210-211; *cf.* '714 Patent, 2:30-36. Because Konno's reflecting layer 121 is on the light (photon) incidence side, layer 121 is *frontside*. *Dec.*, ¶211; *Konno*, 8:16-17.

Konno teaches photons (light) are reflected into the photodiode (“photoelectric conversion element 135”), making layer 121 *light trapping*. *Konno*, 8:31-35, 10:14-21, 11:58–12:3; *Dec.*, ¶¶212-213.

Layer 121 *cover[s] the light incident surface* because Figure 3's upper side “is the side for receiving incident photons 132”:



Dec., ¶214; Konno, 8:16-18.

2. Motivation to Combine

A POSITA would have found obvious and been motivated to *at least partially* cover Hwang-099's *light incident surface* with Konno's *frontside light trapping material* (first reflecting layer 121). Dec., ¶¶215-217. Konno expressly motivates the combination, stating first reflecting layer 121 in combination with second reflecting layer 120 "suppress[es] escape of photons from the light entrance window" and improves the "sensitivity of the detector." Konno, 3:20-28, 8:31-35; Dec., ¶215. Like Konno, Hwang-099 includes a similar second reflecting layer (Hwang-099's reflection layer 155) on the pixel semiconductor's first/lower surface.

Claim 1[b], §V.A.5. In the modification, photons initially unabsorbed after entering Hwang-099's pixel reflect between Hwang-099's *backside light trapping material* (reflection layer 155) and Konno's first reflecting layer 121, such that photons reflected from inside the pixel are reflected back into the pixel. *Konno*, Figure 3, 10:14-21, 8:31-35. A POSITA would have appreciated the resultant increase in sensitivity of Hwang-099's image sensor. *Dec.*, ¶¶215-216. The modification merely requires combining known prior art elements (the light incident surface of a pixel substrate and a reflective metal layer) using known methods ("adher[ing]" the metal layer "to the substrate [] with adhesive," per Konno) to obtain predictable results (a pixel with a *frontside light trapping material* to reflect light back to photosensitive pixel elements). *Konno*, 8:27-28; *Dec.*, ¶217.

The combination would have a REOS, at least because Konno provides methods of forming reflective films, and a POSITA would have the expertise to adjust any forming steps to accommodate the Hwang-099 image sensor. *Dec.*, ¶218; *Konno*, 11:43-57. Reflective layers like Konno's were well-known in the art, thus indicating POSITAs knew how to integrate reflective layers in image sensors. *Id.*

B. Claim 14

Konno teaches reflecting layer 121 (*frontside light trapping material*) is a *reflective layer*. Claim 12, §IX.A.1. Reflecting layer 121 also includes an *aperture*, namely light entrance window 128:

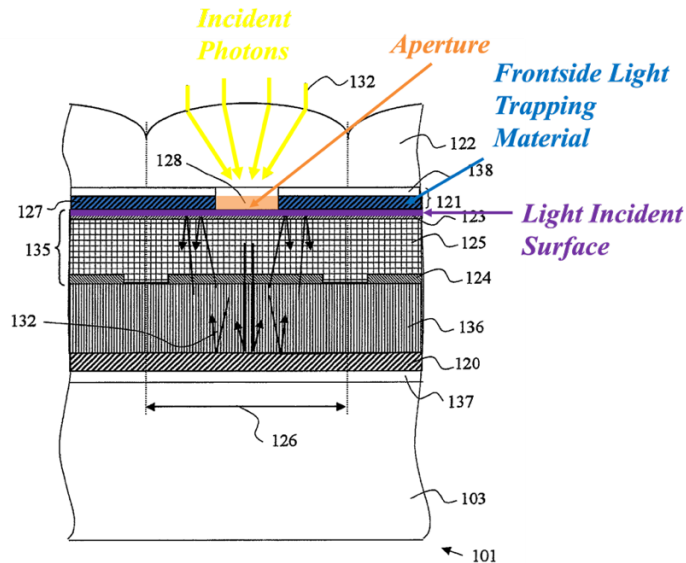


Fig.3

Dec., ¶220. Layer 121 includes window 128 to allow entry of light into the pixel: “[T]he light entrance window 128 through which the incident photons 132 transmit is formed in the first reflecting layer 121.” *Konno*, 8:56-60, 9:4-9 (discussing microlens 122 “leads [photons] to the light entrance window 128”), 4:52-53, 5:5-9.

Konno’s first reflecting layer 121 is operable to reflect light... because layer 121 operates with layer 120, such that “photons can reciprocate between the first reflecting layer [121] and the second reflecting layer [120] many times.” *Konno*, 3:20-29, 8:40-55, 10:4-8, Figure 3; *Dec.*, ¶221; Claim 12, §IX.A.

Claim 12’s mapping modifies Hwang-099 to include *Konno*’s first reflecting layer 121. Claim 12, §IX.A. *Konno* also teaches first reflecting layer 121 includes light entrance window 128; the combined Hwang-099-*Konno* for Claim 14 has a

frontside light trapping material having an *aperture* (Konno's light entrance window). A POSITA would have found obvious and been motivated to include an aperture in the frontside light trapping layer, per Konno, to allow photons to enter the pixel, at least because photon incidence on the image sensor is needed to detect the image. *Dec.*, ¶222; *Konno*, 2:56-67. The combination would have a REOS at least because Konno discloses how to form the window in the layer 121. *Dec.*, ¶223; *Konno*, 8:56–9:3, 9:58–10:13.

C. Claim 15

Hwang-099 teaches a *lens*, namely microlens 230. *Hwang-099*, 8:17-22, Figure 2; *Dec.*, ¶224.

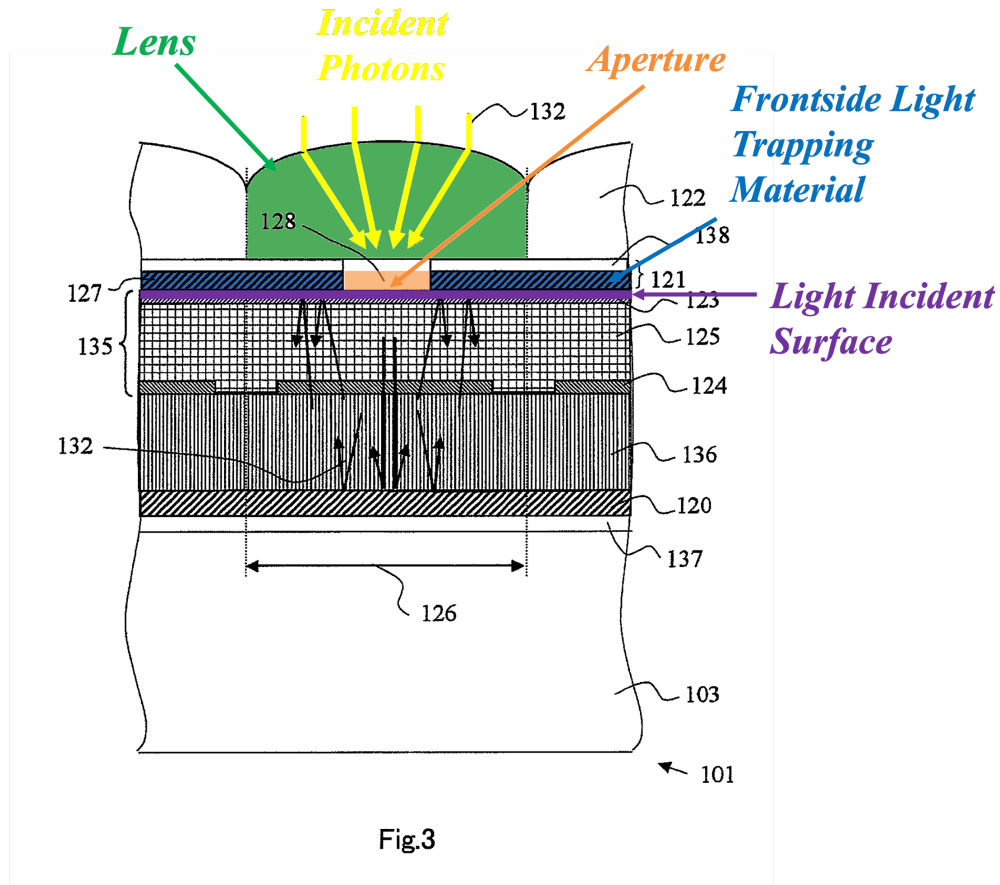
Like Hwang-099, Konno teaches a *lens*, namely microlens 122. *Konno*, 8:25-26, 9:4-9. Konno's lens 122 satisfies the remainder of Claim 15 because:

(1) “microlens 122 is disposed on the first reflecting layer 121[,]” comprising light entrance window 128 (*functionally coupled to the aperture*);

(2) microlens “**concentrates photons...and leads them to the light entrance window 128**” (*operable to focus incident light through the aperture*); and

(3) “[p]hotons which entered...from the light entrance window 128...**reach the photoelectric conversion film 125[,]**” wherein they “are absorbed and cause photoelectric conversion” (*and into the pixel*).

Konno, 8:27-30, 8:56-60, 9:4-9, 9:28-32.



Dec., ¶226.

In the combination for Claims 12, 14, Hwang-099 is modified to include Konno’s frontside reflective layer having an aperture. Claims 12, 14, §§IX.A-B. For Claim 15, a POSITA would have found obvious and been motivated to further modify Hwang-099-Konno to include a lens *functionally coupled to the aperture*....

Dec., ¶228. In the modified Hwang-099 including Konno’s reflective layer 121, it would have been obvious to either (1) modify Hwang-099’s microlens 230 to be “disposed on [Konno’s] first reflecting layer” to thereby be *functionally coupled to the aperture* and *operable to focus incident light*; or (2) replace Hwang-099’s

microlens 230 with Konno's microlens 122 disposed on the first reflecting layer 121.

Dec., ¶228; *Konno*, 8:25-26.

Konno expressly motivates the combination in stating lens 122 “concentrates photons” and “leads them to the light entrance window[.]” *Konno*, 9:4-9; *Dec.*, ¶229. Thus, it would be desirable to have a lens functionally coupled to Konno's light entrance window to thereby concentrate light through the window and into the pixel. *Dec.*, ¶229. The combination includes combining prior art elements (a lens and pixel) according to known methods to yield predictable results. *Id.* Lenses were well-known in the art to refract incident light to illuminate a larger amount of light on and/or over the photodiode. *Id.* Thus, this combination would have been well within the expertise of a POSITA with a REOS. *Dec.*, ¶230.

D. Claim 17

Konno teaches a *backside light trapping material* that is a *metal layer*, namely second reflecting layer 120. Konno teaches first and second reflecting layers 121, 120, respectively, “hav[ing] a function of confining photons which entered the solid-state imaging element 110.” *Konno*, 8:31-38. Second reflecting layer 120 covers the backside surface and may be “formed by forming a thin film of metal such as aluminum or silver by deposition.” *Konno*, 8:35-38, 11:42-52.



Fig.3

Dec., ¶232.

A POSITA would have found obvious and been motivated to modify Hwang-099's backside light trapping material with a metal layer, per Konno. *Dec.*, ¶233. Using metal as reflectors in pixels, including as a backside light trapping material, was common prior to the '714 Patent. *Id.* Compared to Bragg reflectors, a metal layer would have offered more broadband reflectivity, as metals typically have a higher index of refraction and, correspondingly, higher reflectivity than some other materials. *Id.* Additionally, metal layers have reduced manufacturing costs as compared to Bragg reflectors. *Dec.*, ¶234. Such a combination is a simple substitution of one known element (metal layer as a backside light trapping material)

for another (a Bragg reflector as a backside light trapping material) to obtain predictable results (e.g., light reflectivity). *Id.*

The combination would have a REOS at least because metal was a widely available material and because techniques for depositing a metal layer in an image sensor were well-known. *Dec.*, ¶¶235-236; *cf.* '714 *Patent*, 8:6-9.

X. GROUND 6: CLAIM 16 IS OBVIOUS OVER HWANG-099, KONNO, AND KIM

Kim teaches an *aperture*, namely openings 107, “occupy[ing] between 70% to 90% of the uppermost surface area of photodiodes 102.” *Kim*, [0015]. In the combination, Hwang-099 modified to include Konno’s light entrance window 128 (*aperture*) is further modified to have an effective surface area of 90%, per Kim, of Hwang-099’s incident light surface. *Dec.*, ¶238; Claim 14, §IX.B.

A POSITA would have found obvious and been motivated to configure the light entrance window of the modified Hwang-099 image sensor to occupy 90% of the *incident light surface total surface area*, per Kim, to allow for increased light entry to the photodiode. *Dec.*, ¶238. Konno is silent as to the effective surface area of its light entrance window. A POSITA would have recognized having an aperture with a surface area of 90% would have allowed for Hwang-099’s modified image sensor to be used at a larger dynamic range of intensity (e.g., light vs. dark imaging conditions) compared to an aperture occupying less than 90% of the light incident surface. *Id.* Such a modification is use of a known technique (large surface area

apertures, per Kim) to improve similar devices (improving the modified Hwang-099's aperture/light entrance window to have a 90% effective surface area) in the same way as Kim. *Dec.*, ¶¶238-239. Additionally, there are a finite number of percentage surface areas that the aperture can extend, indicating to a POSITA the obviousness of selecting from such finite number in designing the image sensor. *Dec.*, ¶240. The modification would have a REOS at least because Kim teaches the aperture can occupy 90% of the light incident surface. *Id.*

XI. GROUND 7: CLAIM 18 IS OBVIOUS OVER HWANG-099 IN COMBINATION WITH MOULI AND/OR NOZAKI

Mouli teaches a sloped trench wall associated with the *peripheral light trapping material*; Nozaki teaches a sloped backside surface associated with the *backside light trapping material*.

A. Mouli's Sloped Trench Wall

1. Mouli's Teachings

Mouli teaches methods of "forming an isolating trench among pixels or other active areas of a semiconductor device." *Mouli*, Abstract. A "deep trench 202" is created in "silicon substrate 200" through "anisotropic etch[ing]." *Mouli*, 4:48-49. Mouli's trench sidewalls are "high conical sidewalls" (*sloped*):

Sloped Surface of Peripheral Sidewall

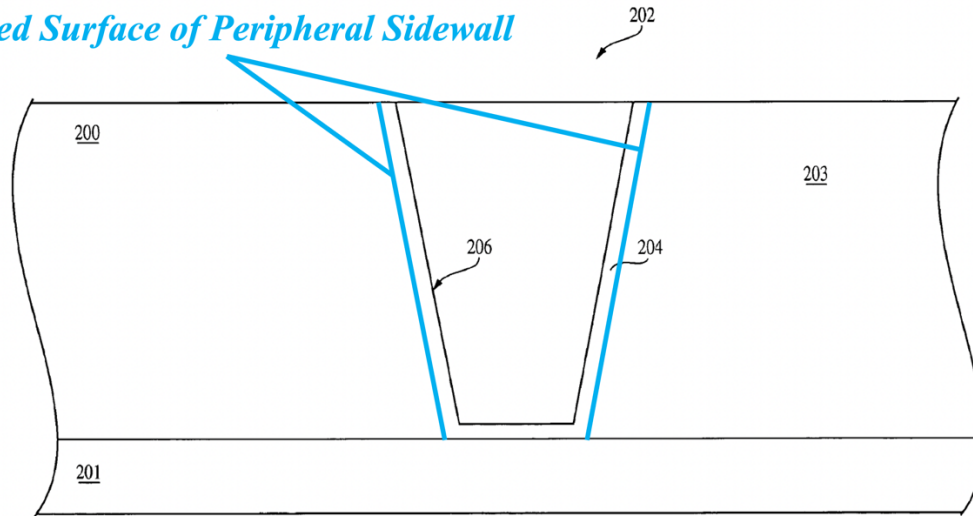


FIG. 3B

Dec., ¶243; *Mouli*, Figure 3B, 5:16-18.

In the combination, Hwang-099's trench sidewall is modified to be sloped, per *Mouli*. Hwang-099's peripheral light-trapping material deposited on the (now modified) sloped trench sidewall at the pixel interface has a commensurate *sloped surface*. *Dec.*, ¶244.

2. *Motivation to Combine*

A POSITA would have found obvious and been motivated to incorporate *Mouli*'s "conical" (*sloped*) trench sidewalls into Hwang-099's pixel layer 110a. *Dec.*, ¶245. Etching trenches into semiconductor substrates commonly causes defects to form. *Dec.*, ¶¶245-247. Passivation of these defects through dielectric layer deposition was a well-known technique but was difficult to achieve on vertical sidewalls. *Dec.*, ¶246. A POSITA would have further known passivation of defects

was significantly improved when a dielectric liner was deposited on a sloped sidewall versus a vertical sidewall. *Id.* A POSITA would have also understood sloped sidewalls improve light collection efficiency. *Dec.*, ¶248. Accordingly, a POSITA would have been motivated to modify Hwang-099 according to Mouli's teachings to form sloped sidewalls to improve the performance of the sensor. *Dec.*, ¶¶245-247. Such a combination represents use of a known technique (sloped sidewalls) to improve similar image sensors in the same way. *Dec.*, ¶248.

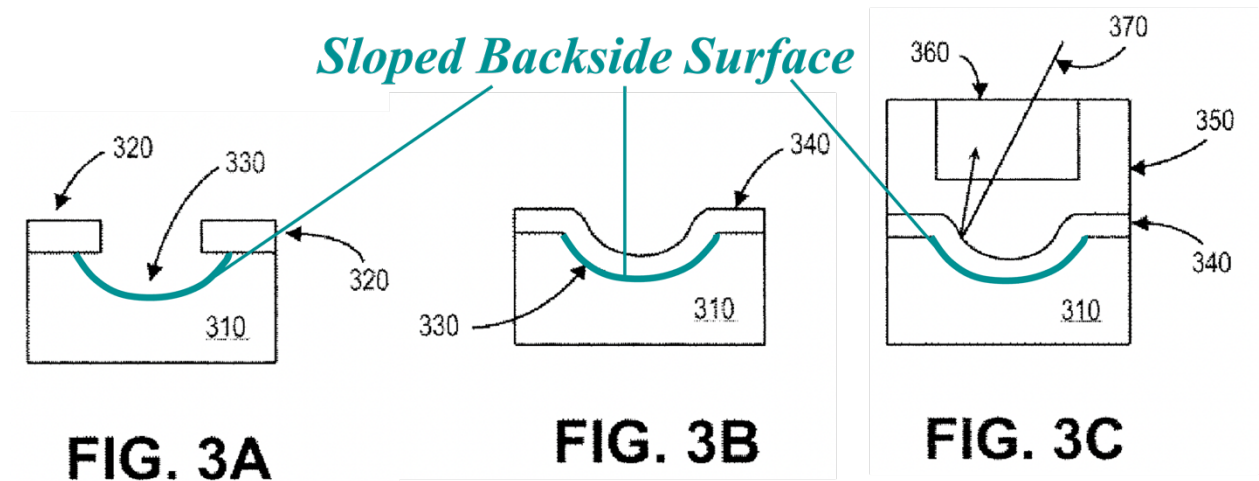
The combination would have a REOS at least because Hwang-099 already discloses etching trenches into the silicon substrate, Mouli discloses forming methods for etching sloped trenches into silicon, both Hwang-099 and Mouli disclose methods for depositing materials on the etched trench sidewalls, and etching sloped trenches was a very well-known and widely used technique. *Dec.*, ¶249.

B. Nozaki's Sloped Backside Surface

1. Nozaki's Teachings

Nozaki teaches a *sloped surface at the pixel device interface of the backside light trapping material*, namely a reflector having a complex-shaped surface. *Nozaki*, Abstract; *Dec.*, ¶¶250-251. Reflectors 140,142,144 “redirect the non-absorbed incident light towards the photodiode.” *Nozaki*, [0018], [0027], Figure 1. A “concave-shaped surface 330 [is] formed within substrate 310[,]” and then a

“reflective layer 340 is conformally deposited across the face of the concave-shaped surface 330.” *Nozaki*, [0035].



Dec., ¶251. Concave-shaped surface 330 is underneath photodiode 360 (Figure 3C) and opposite a surface on which light is incident, thus making Nozaki’s concave-shaped surface a backside surface. *Nozaki*, [0036].

In the combination, Hwang-099’s backside surface is modified to be sloped, per Nozaki. The Hwang-099 backside light trapping material interfacing the (now modified) sloped backside surface at the pixel interface has a commensurate *sloped surface*. *Dec.*, ¶252; Claim 1[b], §V.A.5.

2. Motivation to Combine

A POSITA would have found obvious and been motivated to modify Hwang-099 to have a concave-shaped (sloped) backside surface, per Nozaki. *Dec.*, ¶254. The modification would have resulted in Hwang-099’s reflection layer 155a (*backside light trapping material*) being sloped. *Id.* The complex shape of Nozaki’s

reflectors 140,142,144 allows for “multiple angles of reflection that reflect and focus incident light towards the photosensitive element[,]” thus expressly motivating the combination. *Nozaki*, [0027], [0019]; *Dec.*, ¶254. Additionally, the combination is the use of a known technique (implementing concave-shaped (sloped) backside reflectors) to improve similar image sensors in the same way. *Dec.*, ¶254.

The modification would have a REOS at least because Hwang-099 already discloses a backside surface and methods for forming a *backside light trapping material*, *Nozaki* teaches methods of forming the concave-shaped surface, and methods of providing sloped backside surfaces in pixels were well-known. *Dec.*, ¶255; *Hwang-099*, 8:28–9:34; *Nozaki*, [0034]–[0037].

C. Obviousness of Combining Both Mouli and Nozaki

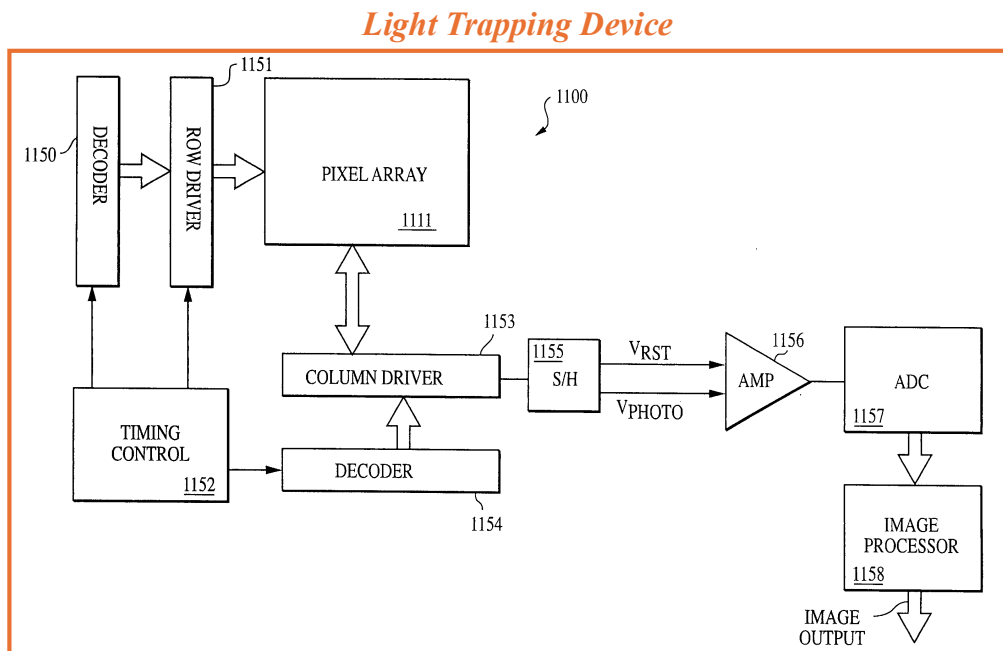
A POSITA would have found obvious and been motivated to modify both Hwang-099’s backside surface (and commensurately, backside light trapping material on the backside surface) and peripheral sidewall (and commensurately, the peripheral light trapping material on the peripheral wall) to have a sloped surface. There is a REOS in each of the individual combinations (§§XI.A.2, XI.B.2). Modifying both the backside surface and peripheral sidewall to be sloped would achieve at least the same benefits as modifying either one of the backside surface or sidewall and there would be no adverse performance in implementing both modifications. *Dec.*, ¶256.

XII. GROUND 8: CLAIMS 1-5, 9-13 ARE OBVIOUS OVER HONG, YAMASHITA, AND HWANG-584

A. Claim 1

1. Claim 1[Pre]: “A *light trapping device*, comprising”

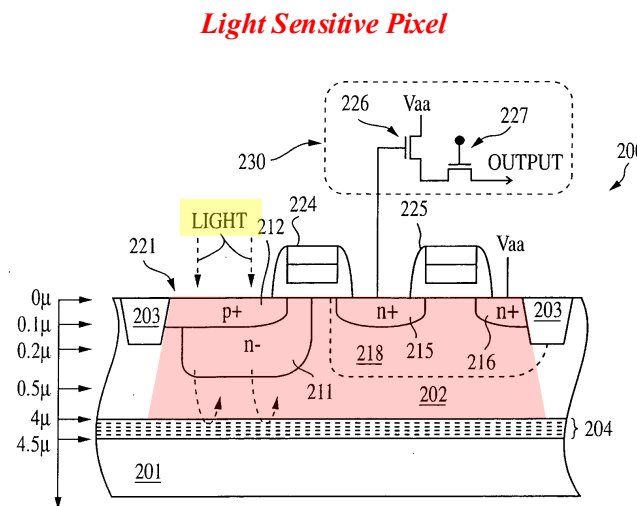
Hong teaches or suggests a *light trapping device*, namely “image sensor 1100 ha[ving] a pixel array 1111 containing a plurality of pixel cells arranged in rows and columns.” *Hong*, [0047], [0029], [0017]-[0018].



Dec., ¶258. Hong’s image sensor 1100 is *light trapping* because each pixel cell of image sensor includes elements “serv[ing] to reflect incident light, not initially absorbed into the photo-conversion device, back to the photo-conversion device.” *Hong*, [0006]; *Dec.*, ¶257.

2. **Claim 1[a]: “at least one light sensitive *pixel*”**

Hong teaches or suggests a *pixel*, namely pixel cell 200 comprising at least semiconductor layer 202 including pinned photodiode 221 (the photo-conversion device comprising “an n-type region 211 underlying a p+ surface layer 212”), floating diffusion region 215, source/drain region 216, and p-well 218, which collectively operate to convert light into an electrical signal. *Hong*, [0017]-[0018]. Hong teaches “[t]he term ‘pixel’ refers to a picture element unit cell containing a photo-conversion device for converting electromagnetic radiation to an electrical signal[.]” *Hong*, [0017].



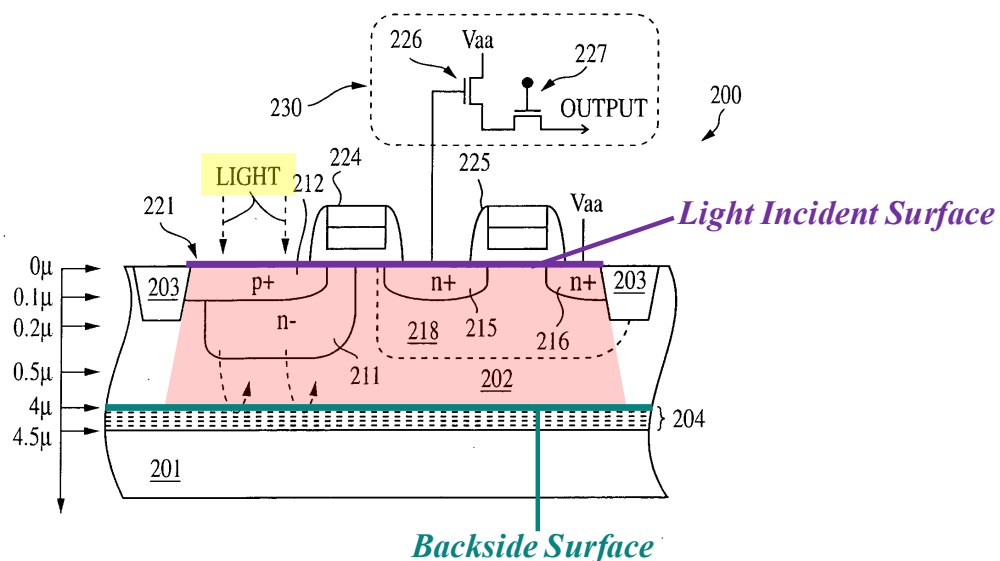
Dec., ¶264; *Hong*, [0009], [0018].

Photo-conversion device (photodiode 221) “convert[s] **electromagnetic radiation** [(e.g., light)] to an electrical signal[.]” and semiconductor layer 202 “is a layer of p-type silicon (Si)[.]” which operates with photodiode to collect electron-hole pairs. *Hong*, [0017], [0022]; *Dec.*, ¶260, ¶¶38-43.

Regarding elements 215,216, transfer transistor 224 “operates to transfer charge from the photodiode 221 to the floating diffusion region 215” (located in p-well 218 with source/drain region 216), where electrical charge is temporarily stored prior to “readout” by readout circuit 230. *Hong*, [0018], [0022], [0048]; *Dec.*, ¶¶261-263. Prior to collecting charge, “the reset transistor 225 resets the floating diffusion region 215 to a predetermined voltage” provided by source/drain region 216, which is “connected to” “array voltage V_{aa} .” *Hong*, [0021]. Elements 215,216, therefore, also assist in collecting and converting light into an electrical signal, qualifying as **a light sensitive pixel**. *Dec.*, ¶¶262-264.

3. **Claim 1[a][i]: “having a light incident surface, a backside surface opposite the light incident surface”**

Hong’s **pixel** has a **light incident surface**, namely a top surface of semiconductor layer 202, shown by at least the purple line on top of pixel cell 200:



Dec., ¶265; *Hong*, [0022] (“transfer and reset transistors 224, 225, and photodiode 221 are located at a surface of a semiconductor layer 202”). Because the top surface of semiconductor layer 202 is a part of the claimed *pixel*, *Hong* teaches the *pixel* has a *light incident surface*. *Dec.*, ¶265; *cf.* ’714 *Patent*, 6:63-65, 13:49-50 (equating top surface of pixel with light incident surface).

The top surface of layer 202 is a *light incident* surface because light is incident on an exposed top surface of the pixel when the image sensor array is in use. *Hong* expressly teaches “[l]ight...incident on photodiode 221[.]” illustrated with the original text “LIGHT” in Figure 2. *Hong*, Figure 2, [0026], [0022], [0018]. Additionally, *Hong* teaches, suggests, or renders obvious light is incident on the entire exposed top surface of layer 202 and not just the portion of the top surface of the layer coinciding with the photodiode. *Dec.*, ¶266 (explaining because Figure 2 is a cross-sectional view of pixel, at least a portion of a width of the pixel includes a light incident surface coinciding with the purple line).

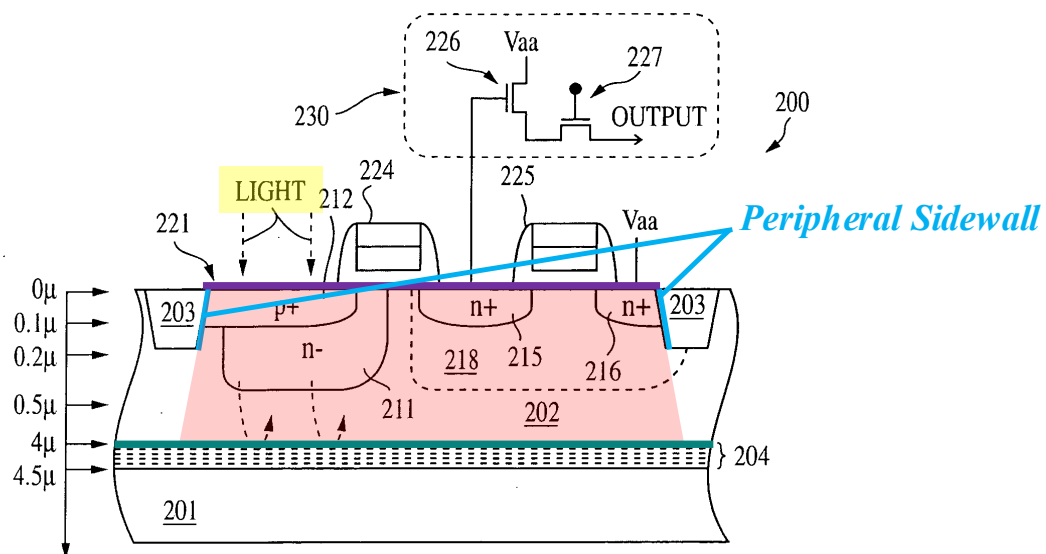
Hong also teaches a *backside surface* opposite the *light incident surface*, namely a bottom surface of semiconductor layer 202 indicated by the teal line in Figure 2, above, and opposite the *light incident surface*.

4. *Claim 1[a][ii]: “a **peripheral sidewall** disposed into at least a portion of the **pixel** and extending at least substantially around the pixel periphery”*

Hong-Yamashita teaches, suggests, or renders obvious Claim 1[a][ii]. In the combination, Hong's peripheral sidewall is modified to extend substantially around the pixel periphery, per Yamashita.

a) Hong's Teachings

Hong teaches a *peripheral sidewall*, namely a wall of isolation region 203. Isolation region 203 is a “shallow trench isolation (STI) region” “formed in the Si layer 202 and filled with a dielectric material.” *Hong*, [0018], [0033], [0021] (STI region 203 “adjacent” source/drain region 216), [0018] (photodiode 221 “adjacent” to isolation region 203).

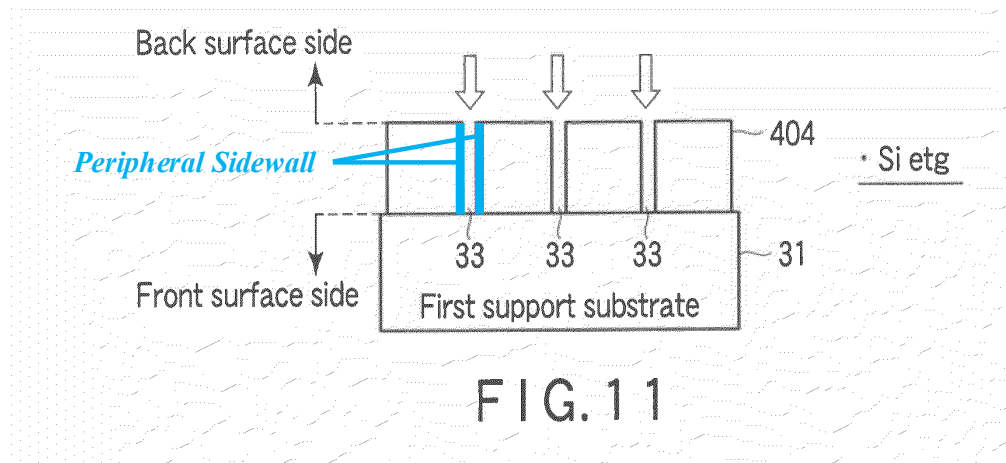


Dec., ¶269.

The sidewall of trenched isolation region 203 is a *peripheral sidewall* disposed into at least a portion of the pixel because the “trench” is “formed in” the semiconductor layer 202 (where layer 202 is part of the *pixel*) and on a periphery of pixel cell 200. *Hong*, [0033], Figure 2; *Dec.*, ¶¶269-270; *cf.* '714 Patent, 11:21-22 (“It is also noted that the pixel sidewall is also known as a trench.”).

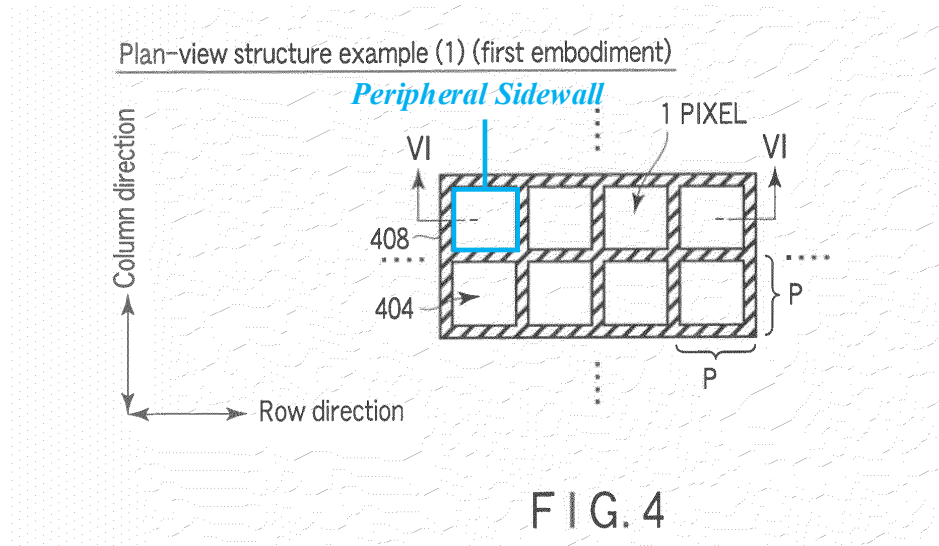
b) Yamashita’s Teachings

Similarly, Yamashita teaches a *peripheral sidewall*, namely sidewall of trench 33. Trench 33 is etched through silicon substrate 404 from the “back side” “to the surface of the first support substrate 31” on the “front side” of substrate 404. *Yamashita*, [0100], [0102], Figures 10-11. *Dec.*, ¶¶271-273. Like *Hong*’s isolation region 203 formed in Si layer 202 (*Hong*, [0033]) being part of the *pixel*, Yamashita’s trench 33 formed in substrate 404 is part of a *pixel* (e.g., Yamashita’s unit pixel 1) because “photodiode 2 [] is provided in the silicon substrate 404” and “photodiode 2 constitutes the photoelectric conversion unit.” *Yamashita*, [0061], Figure 6. Because Yamashita’s trench 33 extends through silicon substrate 404 (from the front to the back side), and substrate 404 is part of a pixel, a sidewall of the trench likewise extends through the substrate and is *disposed into at least a portion of the pixel*:



Dec., ¶273.

Yamashita's sidewall of trench 33 is a *peripheral sidewall* extending at least substantially around the pixel periphery. Yamashita teaches device isolation insulation film 408 is formed by filling trench 33 with “an insulative material, such as a silicon oxide film.” Yamashita, [0104], [0102], Figures 11-12. Film 408 (i.e., filled trench 33) “is disposed in a **lattice shape** in a manner to **surround the unit pixels 1** in the row direction and column direction.” Yamashita, [0076]-[0077], [0084], [0092], [0095], [0104], [0116], Figure 4.



Dec., ¶274. Because film 408, comprising trench 33 that in turn comprises trench wall (*sidewall*), completely surrounds pixel 1, Yamashita’s sidewall is peripheral to the *pixel* and extend[s] substantially around the pixel periphery, per Figure 4. *Id.*

c) Motivation to Combine

A POSITA would have found obvious and been motivated to combine Hong and Yamashita to *extend* Hong’s sidewall of isolation region 203 *substantially around the pixel periphery*. Dec., ¶275. A POSITA would have understood and found desirable extending isolation region 203 around each pixel 200 to reduce or eliminate crosstalk between pixels in Hong’s pixel array 1100. *Id.* Yamashita also expressly motivates the combination, stating “device isolation insulation film 408 is continuously formed in a **lattice shape along pixel boundaries** without spacing, as shown in FIG. 4” so that “light is reflected at the device isolation insulation film 408 with **no leak**.” *Yamashita*, [0095], [0104]. This helps “prevent [] light from entering

the neighboring unit pixel” so that “crosstalk” “and the occurrence of color mixing can be prevented[.]” *Yamashita*, [0092]-[0093], [0097]. A POSITA would have appreciated Hong’s image sensor with pixel cells 200 having an extended peripheral sidewall would benefit from similarly reduced crosstalk and color mixing. *Dec.*, ¶275.

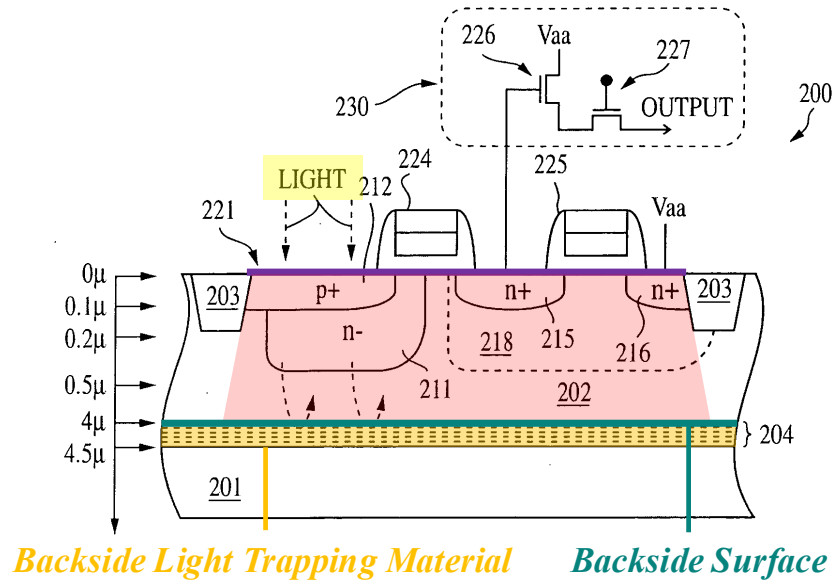
The modification entails using a known technique (etching a trench in a substrate around the pixel periphery, per *Yamashita*) to improve similar devices (improving the performance of Hong’s image sensor pixel) in the same way (reducing crosstalk in Hong’s system in the same manner as *Yamashita*’s). *Id.*

The modification would have a REOS. Both Hong and *Yamashita* comprise analogous trench isolation structures with *peripheral sidewalls disposed into the pixel*, making the combination straightforward and well within a POSITA’s expertise. *Dec.*, ¶¶276-278.

5. ***Claim 1[b]: “a **backside light trapping material** at least partially covering the **backside surface**”***

Hong teaches or suggests a **backside light trapping material**, namely “reflective layer 204 [that] is illustratively a Distributed Bragg Reflector (DBR) mirror including sub-layers....” *Hong*, [0023], Figures 2-3; Claim 1[a][i], §XII.A.3. Like the ’714 Patent, Hong’s “reflective layer 204 has a (first refractive index sub-layer)/(second refractive index sub-layer) periodic structure.” *Hong*, [0025]; *cf.* ’714 Patent, 2:59-64.

Reflective layer 204 (*backside light trapping material*) is *at least partially covering the backside surface* (bottom surface of Si layer 202) because “Si layer 202 overlies a reflective layer 204”:



Dec., ¶281; Hong, [0023].

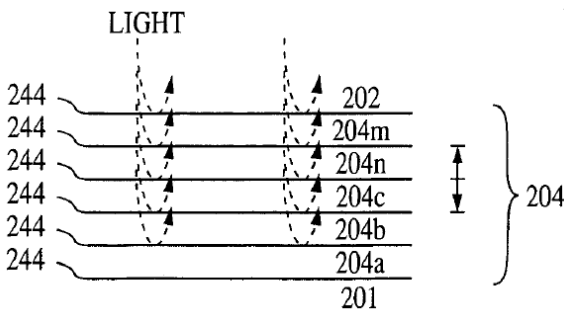


FIG. 3

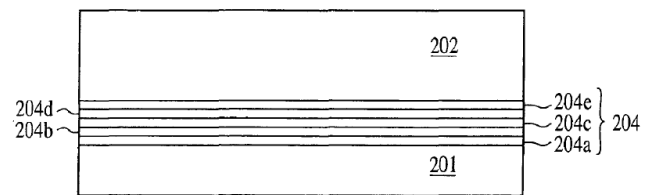


FIG. 5

Hong, Figures 3,5 (illustrating reflective layer 204 (including sublayers) covering the bottom surface of Si layer 202). Dec., ¶¶279-280.

6. **Claim 1[c]: “a *peripheral light trapping material* substantially covering the *peripheral sidewall*”**

In the combination, Hong-Yamashita is combined with Hwang-584, where Hong’s peripheral sidewall of trench is modified to include a *peripheral light trapping material substantially covering the peripheral sidewall*, per Hwang-584.

a) Hwang-584’s Teachings

Like Hong, Hwang-584 teaches a *peripheral sidewall*, namely a “side wall[]” of trench 350. *Hwang-584*, [0024], [0035]-[0036], [0050]⁵, Figure 5B. Hwang-584 teaches Claim 1[c], namely “device separation membrane 300 comprising a silicon dioxide membrane 320 and a silicon membrane 340.” *Hwang-584*, [0025], [0020], [0035]-[0037], Figures 2-3a; *Dec.*, ¶¶283-285.

Trench 350 is formed on p-type epitaxial layer 200, which is an element of Hwang-584’s *pixel* because “photodiodes (400) [are] formed on the epitaxial layer (200)” and photodiode 400 “photoelectric[ally] transform[s]” light. *Hwang-584*, [0009], [0014], [0016], [0019], [0035].

Separation membrane 300 comprises membranes 320, 340 forming “3 layers of membrane” with alternating “membranes of two different materials having different refractive indices[.]” *Hwang-584*, [0020]-[0021], [0024], Figures 5b-5d. Membrane 320 “is formed by first forming a trench on the epitaxial layer and

⁵ Petitioners added paragraph numbers to Hwang-584 for ease of reference.

depositing...(SiO₂) on the bottom surface and **side walls of the trench.**” *Hwang-584*, [0024], [0036]. Membrane 340 is formed when “silicon is charged into the trench where the [SiO₂] membrane (320) is formed[.]” *Hwang-584*, [0037]. As shown in Figures 5b-5d, below, membrane 300 *substantially cover[s] the peripheral sidewall* (sidewall of trench 350):

Figure 5b

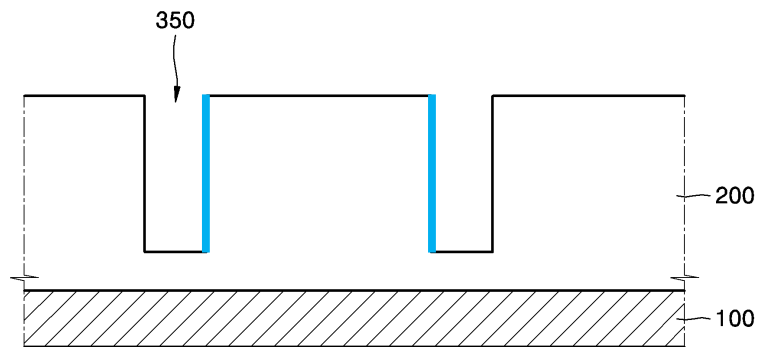
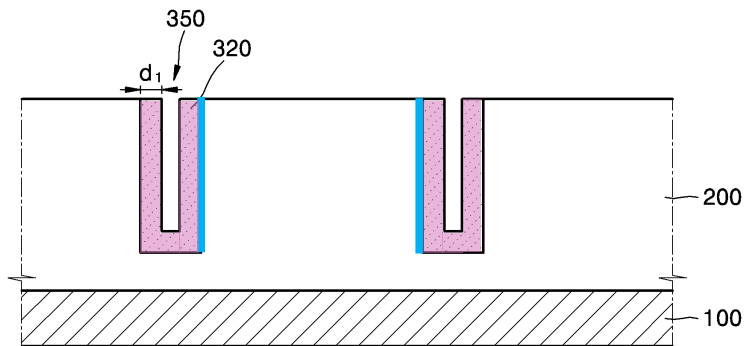
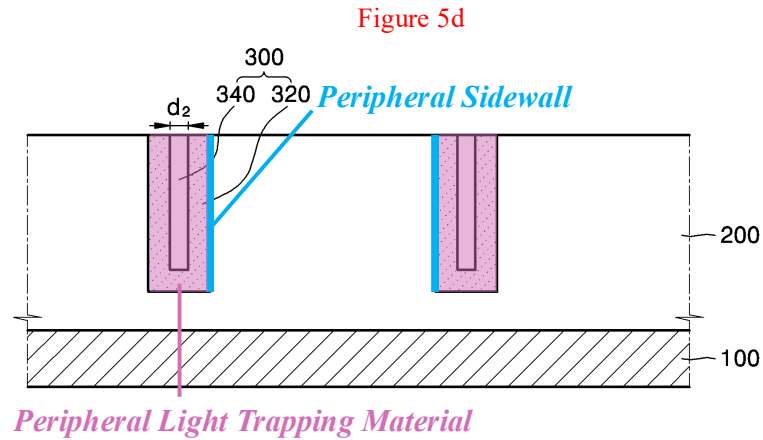


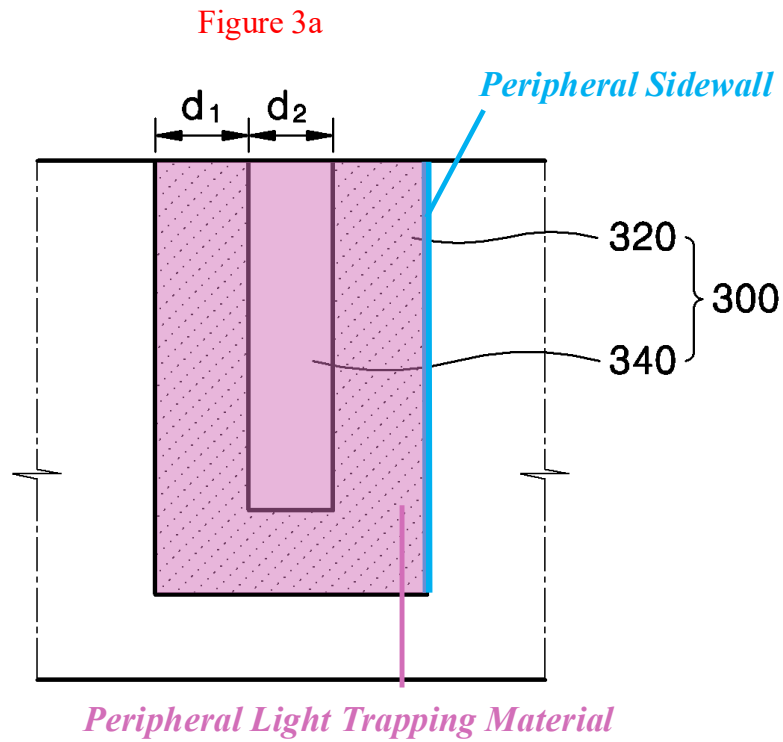
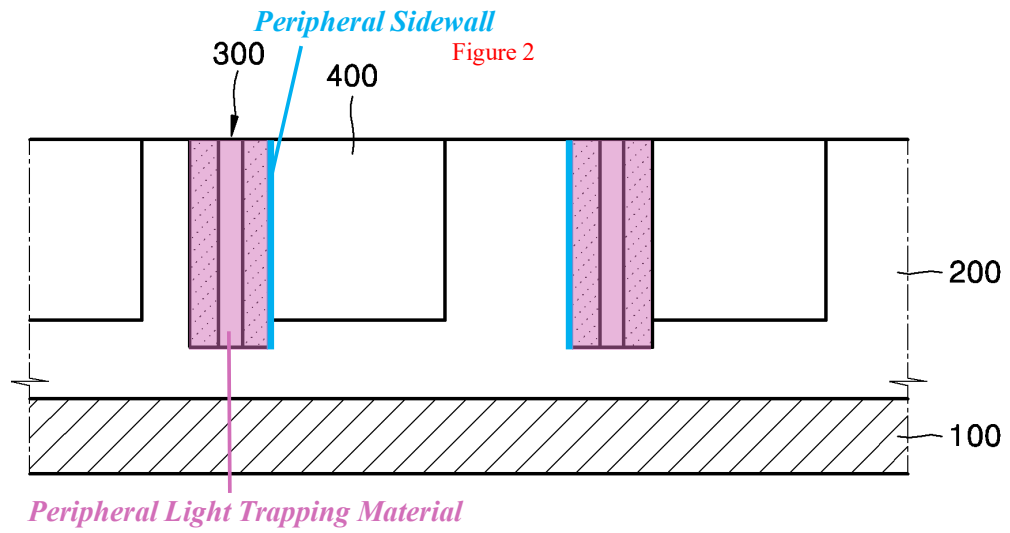
Figure 5c





Dec., ¶286.

Separation membrane 300 is *light trapping* because the difference in the refractive index between membranes 320, 340 raises “the **reflectance** of the device separation membrane...to **block** permeation of side light from entering into an adjacent pixel.” *Hwang-584*, [0020], [0029]-[0031], Figure 4a; *cf.* ’714 Patent, 11:25-30; Dec., ¶289. Further, the “device separation membranes (300) [] **structurally separate** each active region[.]” *Hwang-584*, [0019]. Thus, a POSITA would have understood separation membrane 300 operates to *trap light* within *Hwang-584*’s *pixel*. Dec., ¶289.



Dec., ¶287.

b) Motivation to Combine

A POSITA would have found obvious and been motivated to modify the wall of Hong's trenched isolation region 203 (*peripheral sidewall*) to be *substantially cover[ed]* by Hwang-584's device separation membrane 300 (*peripheral light trapping material*). *Dec.*, ¶290.

In the combination, Hong's trench completely peripherally surrounds the pixel, per Yamashita (Claim 1[a][ii], §XII.A.4), and is further modified to include Hwang-584's *peripheral light trapping material* substantially covering Hong's *peripheral sidewall*. *Dec.*, ¶291. Hwang-584 expressly motivates the combination, discussing the benefit of "reflect[ing] most of [the] long wavelength[s] of light" back into pixel 200. *Hwang-584*, [0032], [0020], [0025]; *Dec.*, ¶291. Further, a POSITA would have understood replacing a single dielectric layer with "different materials having different refractive indices" in isolation trench 203 (thus *covering the peripheral sidewall*) would have greater reflectivity than just the singular "dielectric material" taught by Hong. *Id.*; *Hong*, [0033]; *Dec.*, ¶292. A POSITA would have thus appreciated significantly reducing crosstalk between pixels due to separation membrane 300. *Dec.*, ¶291. The modification is a simple combination of prior art elements (a peripheral sidewall surrounding a pixel and materials having different refractive indices) to yield predictable results (improved entrapment of light within a pixel). *Dec.*, ¶293.

The combination would have a REOS given a POSITA would know how to form a trench and deposit the layered materials on the peripheral sidewall, as disclosed in Hwang-584. *Hwang-584*, [0023]-[0024]; *Dec.*, ¶294-295. Further, Hong's trenched isolation element 203 is originally filled with "an oxide material" "such as...SiO₂[,]" which is the same material used for membrane 320 in Hwang-584's device isolation membrane 300. Therefore, the combination would have only required "filling silicon (Si) between the silicon dioxide layers (320)[,]" where silicon dioxide is already present in isolation element 203. *Hwang-584*, [0024], Figure 3a; *Dec.*, ¶294-295.

7. *Claim 1[d]: "wherein light contacting the backside light trapping material or the peripheral light trapping material is reflected back toward the pixel"*

a) **Hong's Backside Light Trapping Material**

Hong teaches *light contacting the backside light trapping material* (reflective layer 204) *is reflected back toward the pixel*. "The reflective layer serves to **reflect incident light** not initially absorbed into the photoconversion device, **back to the photo-conversion device**[,]" where the photo-conversion device is part of the *pixel*. *Hong*, Abstract, [0006], [0023], Figure 3; *Dec.*, ¶297; Claim 1[b], §XII.A.5.

b) **Hwang-584's Peripheral Light Trapping Material**

Hwang-584 teaches *light contacting the peripheral light trapping material* (Hwang-584's device separation membrane 300) *is reflected back toward the pixel*. Hwang-584 teaches membrane having two separate membranes of "different

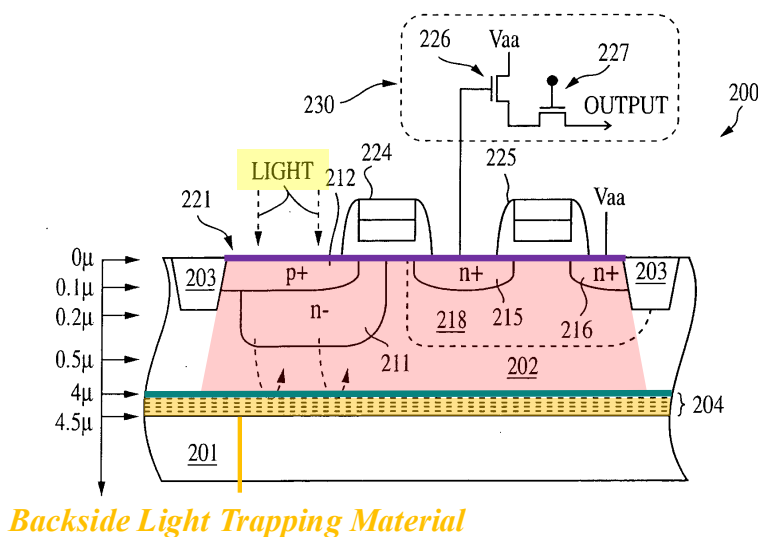
refractive indices can **reflect** most of long wavelength of **light**, especially the visible light range, thereby significantly reducing CT [(crosstalk)] phenomenon[.]” *Hwang-584*, [0009], [0032], [0020], [0041], [0001], Figure 4a; *Dec.*, ¶298.

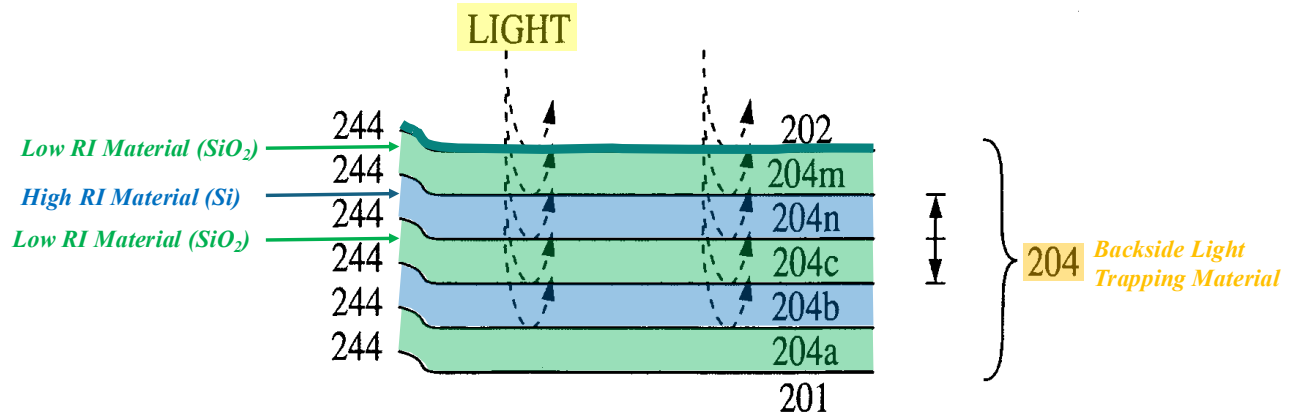
In the combination for Claim 1[c], the modified Hong is further modified to include Hwang-584's *light trapping material*. The motivations to combine Hong-Yamashita-Hwang-584, which specifically discuss reflection of light back toward the pixel, are discussed for Claims 1[a][ii], 1[c] (§§XII.A.4.a)-XII.A.4.c), XII.A.6.a)XII.A.6.b)), incorporated herein. *Dec.*, ¶299.

8. *Claim 1[e]: “wherein at least one of the **backside light trapping material** or the **peripheral light trapping material** includes a **high refractive index material** sandwiched between two **low refractive index materials**”*

a) Hong's Backside Light Trapping Material

Hong's *backside light trapping material* (reflective layer 204; §XII.A.5) meets Claim 1[e].





Dec., ¶¶301-302.

Hong’s reflective layer 204 comprises alternating layers of low/high refractive index materials to form a *sandwich*[/] that “is illustratively a Distributed Bragg Reflector (DBR) mirror[.]” *Hong*, [0023]; *Dec.*, ¶302. Hong’s “layer 204 can be formed having an SiO₂/Si structure. In such a case sub-layers 204*a*, 204*c*, and 204*m* are SiO₂ sub-layers and sub-layers 204*b* and 204*n* are Si sub-layers.” *Hong*, [0031]. “Therefore, each sub-layer 204*a-m* is in contact with material having a **different refractive index** to form a (first refractive index layer)/(second refractive index layer)” “periodic structure.” *Hong*, [0023], [0031], Figures 2-3; *cf* ’714 *Patent*, 9:18-19. Hong thus teaches a *sandwich*[/] of one material having a first refractive index sandwiched between two materials having a second refractive index. *Dec.*, ¶302.

Additionally, Hong expressly teaches the sub-layers include materials of high/low refractive indexes because one layer has a “first refractive index” “different” from a “second refractive index.” *Hong*, [0023]. Applying common

sense, if one layer is a first refractive index and a second layer is a second, different refractive index, then one layer is a higher refractive index than the other layer. *Dec.*, ¶303. Because Hong describes layers alternating between first/second refractive indexes, Hong further teaches a *high* refractive index material sandwiched between two *low* refractive index materials, regardless of whether the first material is the low or high-refractive index material. *Id.*

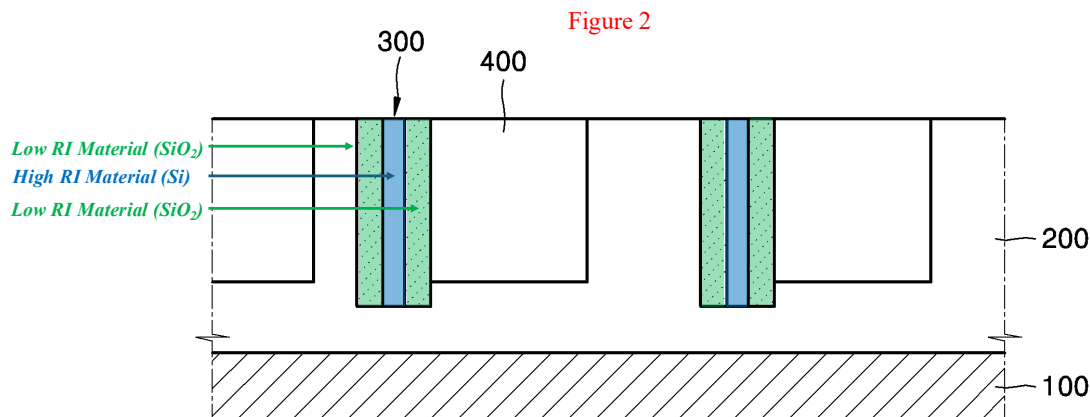
Additionally or alternatively, Hong alone teaches or suggests the claimed high/low refractive indexes or such would be obvious based on the knowledge of a POSITA because Hong teaches the sub-layers are a “SiO₂/Si structure.” *Hong*, [0031]; *Dec.*, ¶304. Although Hong is silent to the refractive indexes for SiO₂ and Si, a POSITA would have known such refractive indexes. *Dec.*, ¶304. A POSITA would have known from at least Hwang-584 that SiO₂ (silicon dioxide) layer has a refractive index of “around 1.46” and Si (silicon) layer has a refractive index of “around 3.7 to 5.7 depending on the wavelength” of incident light. *Hwang-584*, [0025]; *Dec.*, ¶304. Therefore, Hong alone teaches or suggests the refractive indexes of its high refractive index material (Si) and low refractive index material (SiO₂) or such would be obvious based on the knowledge of a POSITA as evidenced by at least Hwang-584. *Dec.*, ¶304.

To the extent SiOnyx argues Hong does not teach or suggest the claimed high/low refractive indexes or such would not be obvious to a POSITA based on the

POSITA's knowledge, it would have been obvious to use Hwang-584's high refractive index material (Si) sandwiched between two low refractive index materials (SiO₂) in Hong's similar sandwich of SiO₂/Si layers. *Dec.*, ¶305. Both Hong and Hwang-584 teach a sandwich of periodic high/low refractive index layers, including both teaching alternating layers of SiO₂ and Si. Therefore, it would be obvious to use, in Hong's image sensor, the periodic SiO₂/Si layers taught in Hwang-584 for achieving the specific refractive indexes with a low-high-low sandwich. *Id.* There would be a REOS because the refractive index of the same materials in Hwang-584's separation membrane 300 (for deposition on a peripheral sidewall) would have the same refractive index when used in Hong's reflective layer 204 (*backside light trapping material*). *Id.* (noting Hwang-584's separation membrane is disposed on a peripheral sidewall, and not a backside surface, but the refractive indexes of the utilized materials would be the same in both applications); §XII.A.6. Indeed, even the '714 Patent's claims do not differentiate between whether the low vs. high refractive index material is covering the claimed peripheral wall or the backside surface, as dependent Claims 2-6 simply recite properties of one of the two materials without claiming the material is the peripheral vs. the backside light trapping material.

b) Hwang-584's Peripheral Light Trapping Material

Hwang-584's *peripheral light trapping material* (device separation membrane 300 comprising layers of silicon dioxide membrane 320 and silicon membrane 340; §XII.A.6) is a *sandwich* because silicon layer 340 is “formed” “between” layers of silicon dioxide 320. *Hwang-584*, [0024]. Membranes 320, 340 are “two different materials having different refractive indices[.]” *Hwang-584*, [0020], [0032].



Dec., ¶306.

Hwang-584 teaches “silicon dioxide’s refractive index is around 1.46, whereas that of silicon is around 3.7 to 5.7 depending on the wavelength. Therefore, the difference between the refractive indices is 2.2 or more, allowing high reflectance in a device separation membrane (300) comprising a silicon dioxide membrane (320) and a silicon membrane (340).” *Hwang-584*, [0025], Figure 3a. Therefore, Hwang-584’s *peripheral light trapping material* (membrane 300 comprising membranes 320, 340) *includes a high refractive index material*

(membrane 340's silicon having a refractive index of at least around 3.7) *sandwiched between two **low refractive index materials*** (layers of membrane 320 on either side of membrane 340, where membrane 320's silicon dioxide has a refractive index of around 1.46). *Dec.*, ¶306.

c) Motivation to Combine

See Claim 1[c], §XII.A.6.b).

B. Claim 2

The mapped *two low refractive index materials* (SiO₂) in both the peripheral and backside light trapping materials are around 1.46, *less than about 2.1*. *Hwang-584*, [0025]; *Dec.*, ¶307; Claim 1[e], §XII.A.8.

C. Claim 3

The *low refractive index material* is silicon dioxide, *a member* of the claimed group *oxide*. *Dec.*, ¶308; *Hong*, [0033]; Claim 1[e], §XII.A.8.

D. Claim 4

The *low refractive index material* is silicon dioxide, a member of the *silicon oxide* group. *Dec.*, ¶309; Claim 1[e], §XII.A.8.

E. Claim 5

The *high refractive index material* for both the backside and peripheral light trapping materials is silicon with a refractive index of at least 3.7, which is *greater than or equal to about 2.1*. *Hwang-584*, [0025]; *Dec.*, ¶310; Claim 1[e], §XII.A.8.

F. Claim 9

See Claim 1[e], §XII.A.8. Both Hong and Hwang-584 teach a first material Si having a refractive index of at least around 3.7 and a second material SiO₂ having a refractive index of 1.46 (difference of 2.24, which is *at least 0.2*). Dec., ¶¶311-314.

G. Claim 10

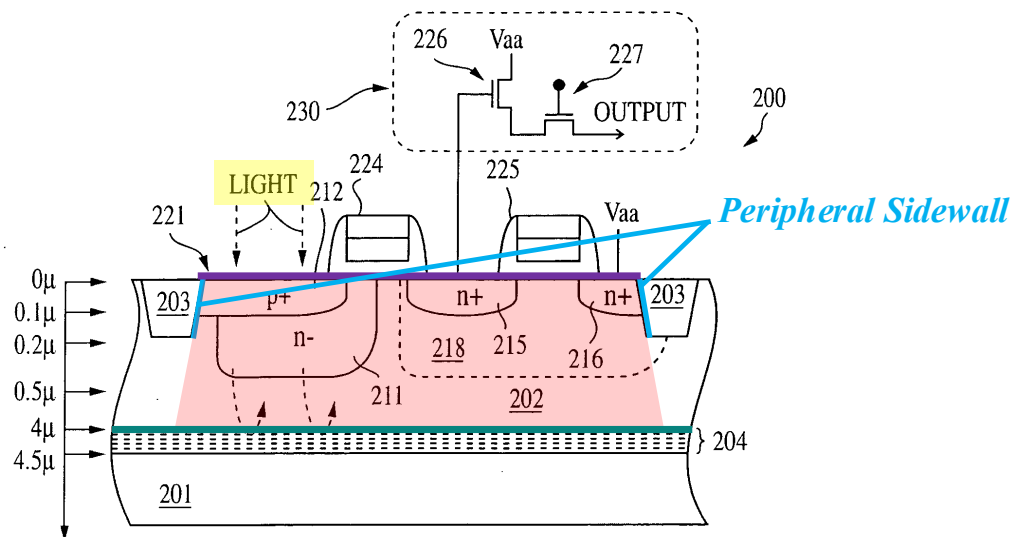
See Claim 1[a][ii], §XII.A.4.

H. Claim 11

1. Hong's and Yamashita's Teachings

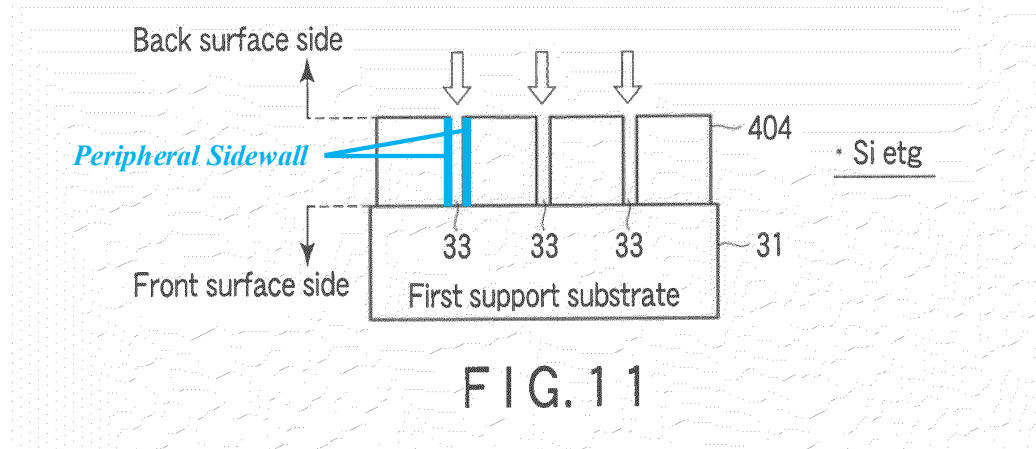
Yamashita combined with Hong's peripheral sidewall teaches Claim 11.

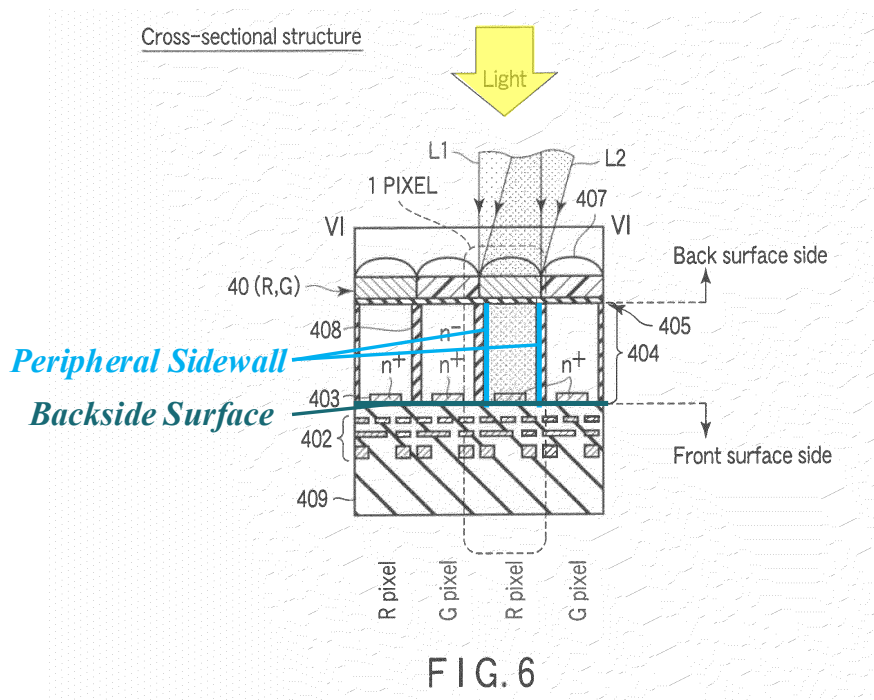
Hong teaches a *peripheral sidewall* (wall of isolation region 203).



Dec., ¶317; Hong, [0018], [0033]; Claim 1[a][ii], §XII.A.4.a). Hong's wall of isolation region 203 *extends from the light incident surface*, i.e., from the top surface of semiconductor layer 202 indicated with a purple line in the above Figure 2. Dec., ¶317; Claim 1[a][i], §XII.A.3.

Yamashita similarly discloses a pixel having a *peripheral sidewall*, namely sidewall of trench 33, where trench 33 is filled with an insulative material to form device insulation film 408. Claim 1[a][ii], §XII.A.4.b).



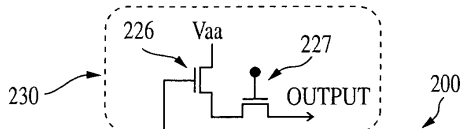


Dec., ¶318.

Yamashita's sidewall of trench 33, which is filled with insulative material to form the film 408 identified in Figure 6, *extends...to the backside surface* of the pixel. *Dec.*, ¶318 (explaining Figure 6's originally-labeled "front surface side" is the *backside surface* of the pixel; Yamashita's labeling refers to the disclosed forming methods). Yamashita expressly teaches forming the trench 33, and therefore the trench wall (*peripheral sidewall*), from the surface that is the light-receiving region (Yamashita's "back surface side" in Figure 6) to the opposite surface (Yamashita's "front surface side" in Figure 6). *Dec.*, ¶318. Because the trench is formed "**to the surface**" of substrate 31 (*Yamashita*, [0102]), Yamashita teaches or suggests the trench (and therefore, the trench wall) *extends...to the backside surface. Id.*

2. *Motivation to Combine*

In the combination, Hong's sidewall of trenched isolation region 203 is modified to extend to Hong's *backside surface*, namely Hong's bottom surface of substrate 202 opposite the light incident surface, per Yamashita. *Dec.*, ¶319. The *light incident* and *backside surfaces* are shown again in Figure 2:



Dec., ¶319; Claim 1[a][ii], §XII.A.4. A POSITA would have found obvious and been motivated to modify Hong’s peripheral sidewall to extend from the light incident surface to the backside surface of Hong, per Yamashita, to prevent when “light enters the neighboring pixel beyond an inter-pixel boundary” “leading to crosstalk and color mixing.” *Yamashita*, [0093]; *Dec.*, ¶¶320-321.

The modification entails using a known technique (etching a trench sidewall through a substrate, per Yamashita) to improve similar devices (improving Hong's pixel performance) in the same way (improved isolation between pixels in Hong's image sensor array, like Yamashita's). *Dec.*, ¶¶320-321.

The modification would have a REOS well within the expertise of a POSITA, at least because Yamashita already teaches methods of forming the sidewall to extend to the backside surface, and sidewalls extending through a pixel were well-known in the art. *Dec.*, ¶322; *Yamashita*, [0098]-[0102], Figure 11.

I. Claim 12

1. *Yamashita's Teachings*

See Claim 12, §VIII.A.1, mapping Yamashita's teachings (incorporated herein).

2. *Motivation to Combine*

A POSITA would have found obvious and been motivated to further modify the Hong-Yamashita-Hwang-584 combination to cover Hong's light incident surface with Yamashita's antireflection film 405. *Dec.*, ¶324. Reasons for adding antireflection film 405 to Hwang-099's light incident surface were discussed in §VIII.A.2, and such reasons similarly apply to Hong's image sensor and are incorporated herein. Specifically, antireflection films were known to be desirable to prevent light from reflecting off the light incident surface and thereby improve sensor sensitivity. *Dec.*, ¶325. Like with Hwang-099, there would be a REOS in modifying Hong due to the well-known forming methods for adding antireflection films, as otherwise expressly taught in Yamashita. *Yamashita*, [0105]-[0113], Figures 6-7, 16; *Dec.*, ¶326.

J. Claim 13

See Claim 12, §XII.I (incorporated herein). Yamashita's *frontside light trapping material* ("antireflection film 405") is an *antireflective layer coating*. *Dec.*, ¶327.

XIII. GROUND 9: CLAIM 6 IS OBVIOUS OVER HONG, YAMASHITA, HWANG-584, AND KOMURO

Hong-Yamashita-Hwang-584’s high refractive index material is silicon with a refractive index of “around 3.7 to 5.7 depending on the wavelength.” *Hwang-584*, [0025].

A. Komuro’s Teachings

See Claim 6, §VI mapping Hwang-099’s and Komuro’s teachings (incorporated herein).

TABLE 1						
	Refractive Index (n)			Extinction Coefficient (k)		
	Blue Light 450 nm	Green Light 550 nm	Red Light 650 nm	Blue Light 450 nm	Green Light 550 nm	Red Light 650 nm
Germanium	4.5	6.0	5.5	2.3	2.1	1
Silicon	4.69	4.08	3.85	0.151	0.03	0.017
Tungsten	3.31	3.48	3.76	2.47	2.72	2.95
Plasma Silicon Nitride	2.07	2.04	2.01	0.004	0	0.002
Aluminum	0.618	0.958	1.47	5.47	6.69	7.79
Copper	1.17	0.9	0.21	2.39	2.6	3.67
Reference: Silicon Dioxide	1.45	1.45	1.45	0.00	0.00	0.00

Komura, Table 1.

B. Motivation to Combine

A POSITA would have found it obvious and been motivated to implement Hong-Yamashita-Hwang-584’s *high refractive index material* as “any one of single crystal silicon, amorphous silicon, and polysilicon” because each possesses a

refractive index from 3.85 to 4.69 dependent on wavelength (i.e., “around 3.7 to 5.7 depending on the wavelength,” per Hwang-584’s refractive index for silicon). *Komuro*, [0137]-[0138]; *Dec.*, ¶¶330-332; Claim 6, §VI.C.C (incorporating MTC/REOS).

XIV. GROUND 10: CLAIMS 7-8 ARE OBVIOUS OVER HONG, YAMASHITA, HWANG-584, AND HWANG-795

A. Claim 7

1. *Hwang-795’s Teachings*

See Claim 7, §VII.A mapping Hwang-795’s teachings (incorporated herein).

2. *Motivation to Combine*

A POSITA would have found obvious and been motivated to dope Hwang-584’s silicon dioxide membrane 320 in the *peripheral light trapping material* of the Hong-Yamashita-Hwang-584 combination with boron, per Hwang-795, to *create a surface field* and “significantly improve the performance of the image sensor.” *Hwang-795*, [0036]; *Dec.*, ¶334. Hwang-795 expressly motivates doping Hwang-584’s silicon dioxide membrane 320 with boron to improve a pixel’s “charge transfer efficiency” and “minimize...dark current[.]” *Hwang-795*, [0015], [0029]-[0030], [0036]; *Dec.*, ¶335. A POSITA would have recognized the resultant formation of the “channel stop region” after heating silicon dioxide membrane 320 in the modified Hong image sensor would further decrease electrical crosstalk and “increase the

photosensitivity” of the image sensor. *Hwang-795*, [0009], [0017]-[0018], [0028]; *Dec.*, ¶¶336-337.

The modification entails use of a known technique (depositing BSG in a trench), to improve similar pixels in the same way (the modified Hong image sensor’s performance is improved in the same manner, such as decreased electrical crosstalk and improved photosensitivity for better pixel performance in converting light into electrical signals). *Dec.*, ¶337.

The modification would have a REOS given BSG is a well-known material and the deposition techniques are within a POSITA’s expertise. *Dec.*, ¶338.

B. Claim 8

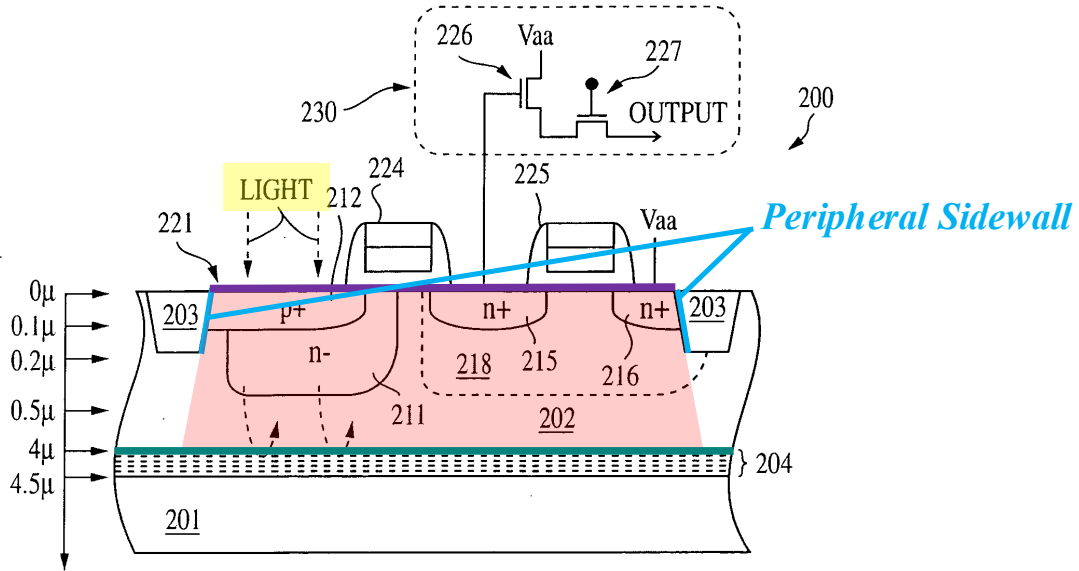
See Claim 7, §§VII.B, XIV.A (incorporated herein), *wherein the dopant is boron*.

XV. GROUND 11: CLAIM 11 IS OBVIOUS OVER HONG, YAMASHITA, HWANG-584, AND MOULI

A. Hong’s and Mouli’s Teachings

To the extent SiOnyx contends Yamashita combined with the modified Hong does not teach Claim 11 (§XII.H), Mouli combined with the modified Hong teaches Claim 11.

Hong teaches a *peripheral sidewall* (wall of isolation region 203):



Hong, Figure 2, [0018], [0033]; Claim 1[a][ii], §XII.A.4.a); Claim 11, §XII.H.1.

Like *Hong*, *Mouli* discloses a pixel having a *peripheral sidewall*, namely sidewalls 210 of trench isolation structure 202. *Mouli*, 3:3-4, 4:10-16, 4:45-53, Abstract, Figures 2, 3A-3C. Like *Hong* and *Yamashita*, *Mouli*'s pixel has a *backside surface*, namely a bottom surface of silicon substrate 200. *Mouli*, 3:35-39, 5:32-40.

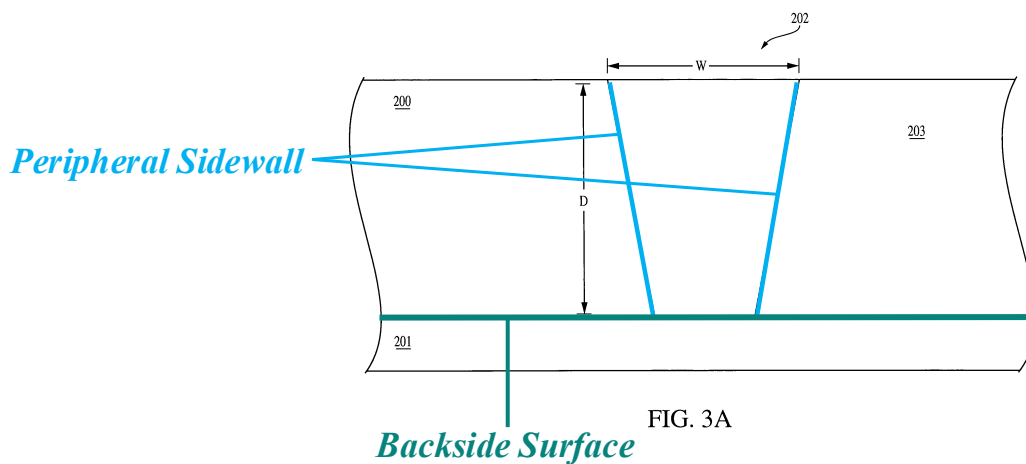


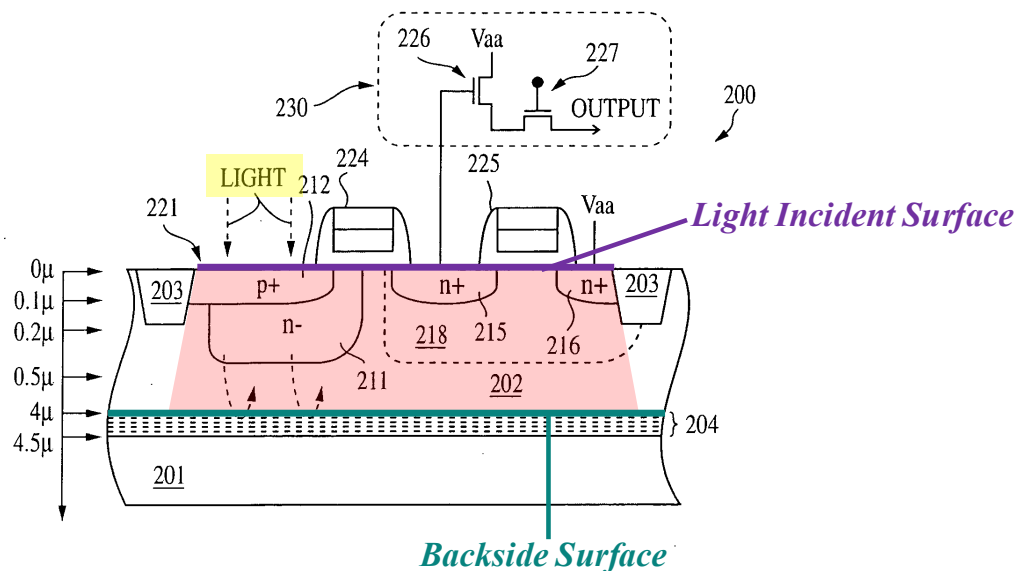
FIG. 3A

Mouli, Figure 3A.

Mouli teaches a peripheral sidewall *extend[ing]...to the backside surface* of pixel because (1) Mouli's sidewall 210 is a sidewall of trench 202; and (2) trench “**extends through the substrate to the base layer**” (*backside surface*) of Mouli's pixel. *Mouli*, Abstract, 4:15-16 (disclosing trench “extend[s]” to epi layer 201, which is below silicon substrate 200), 5:32-34, 4:45-49, 5:50-59, 8:53-59, 9:40-45, Figures 2, 4; *Dec.*, ¶340.

B. Motivation to Combine

In the combination, Hong's sidewall of trenched isolation region 203 is modified to extend to Hong's *backside surface*, namely Hong's surface of substrate 202 opposite the light incident surface, per Mouli:



Hong, Figure 2; Claim 1[a][i], §XII.A.3.

A POSITA would have been motivated and found it obvious to further modify Hong-Yamashita-Hwang-584 to similarly etch Hong's isolation region 203 (and the accompanying sidewall) to *extend[]...to the backside surface*, per Mouli. *Dec.*, ¶341. Mouli expressly motivates the combination, stating a “deeper trench better inhibits electrons from diffusing under the isolation trench to an adjacent pixel thereby preventing crosstalk between neighboring pixels.” *Mouli*, 4:17-32, 2:9-10; *Dec.*, ¶341.

The modification entails using a known technique (etching a deep trench into a substrate, per Mouli) to improve similar devices (improving the performance of Hong's image sensor pixel) in the same way (reducing crosstalk in Hong). *See* §XII.H.2 (providing additional MTC/REOS for etching a deep trench, incorporated herein); *Dec.*, ¶¶341-342.

The modification would have a REOS. *Dec.*, ¶343. Mouli informs a POSITA how to make the trench using a “directional etching process, such as Reactive Ion Etching (RIE)[,]” which was well-known. *Mouli*, 5:57-58; *Dec.*, ¶343; *cf.* '714 *Patent*, 7:60-63. Hong and Mouli are also similarly concerned with “photons having long wavelengths.” *Mouli*, 2:45-46; *cf. Hong*, [0005], *with Mouli*, 2:9-14, 2:32-46. Forming trench isolation features in pixels was well-known, indicating such modifications would have been within the expertise of a POSITA. *Dec.*, ¶343.

XVI. GROUND 12: CLAIMS 12, 14-15, 17 ARE OBVIOUS OVER HONG, YAMASHITA, HWANG-584, AND KONNO

A. Claim 12

1. Konno's Teachings

See Claim 12, §IX.A, mapping Konno's teachings (incorporated herein).

2. Motivation to Combine

Similar to the MTC/REOS provided for modifying Hwang-099 to include Konno's first reflecting layer 121 (§IX.A.2, incorporated herein), a POSITA would have found obvious and been motivated to *at least partially cover* Hong's *light incident surface* with Konno's first reflecting layer 121. *Dec.*, ¶345. In the modification, photons initially unabsorbed after entering Hong's pixel 200 would reflect between Hong's backside light trapping material (reflective layer 204) and Konno's first reflecting layer 121, thus meeting Konno's express motivation of suppressing the escape of photons and improving sensor sensitivity. *Konno*, 3:20-28, 8:31-35; *Dec.*, ¶345. A POSITA would have understood that this modification would have reduced optical color mixing. *Dec.*, ¶346. Thus, a POSITA would have been motivated to combine known prior art elements (the light incident surface of a pixel substrate and a reflective metal layer) using known methods ("adher[ing]" the metal layer "to the substrate [] with adhesive," per Konno) to obtain predictable results (a pixel with a *frontside light trapping material* to reflect light back to photosensitive pixel elements). *Dec.*, ¶347.

The combination would have a REOS, at least because Konno provides methods of forming reflective films, and a POSITA would have the expertise to adjust any forming steps to accommodate the Hong image sensor, including forming Konno's reflective film around Hong's transistors 224, 225. *Dec.*, ¶348; *Konno*, 11:43-57. Reflective layers like Konno's were well-known in the art, thus indicating POSITAs knew how to integrate reflective layers in image sensors. *Dec.*, ¶348.

B. Claim 14

See Claim 14, §IX.B, mapping Konno's teachings (incorporated herein). Like the MTC/REOS provided for Hwang-099, there would have been a similar motivation for including an aperture in Hong's image sensor when modified to include Konno's light reflecting surface. *Dec.*, ¶¶350-351; §XVI.A.2 (MTC/REOS incorporated herein).

C. Claim 15

See Claim 15, §IX.C, mapping Konno's teachings (incorporated herein).

In the combination with Konno, the modified Hong is further modified to include a *lens*, namely Konno's microlens 122. *Dec.*, ¶353. Per the mapping for Claims 12 and 14, Hong is already modified to include Konno's first reflecting layer 121 and light entrance window 128. §§XVI.A-XVI.B (incorporated herein). A POSITA would have found obvious and been motivated to further include Konno's microlens 122 to focus incident light, as it involves combining prior art elements (a

lens and pixel) according to known methods to yield predictable results (a pixel with a lens concentrates incident light through an aperture to convert said light into an electrical signal). Lenses were extremely well-known in the art to “refract incident light to illuminate a larger amount of light on and/or over the photodiode.” *Kim*, [0002]; *Dec.*, ¶¶353-355. Thus, this modification would have been well within the expertise of a POSITA. *Dec.*, ¶356.

D. Claim 17

See Claim 17, §IX.D, mapping Konno’s teachings (incorporated herein).

A POSITA would have found obvious and been motivated to implement Konno’s second reflecting layer 120 as the backside light trapping material in Hong’s pixel 200 because “photons are reflected by the mirror surface of the second reflecting layer 120” from inside the pixel back into the pixel to increase “the detection efficiency and efficiency for conversion into electric signals.” *Konno*, 1:37-38, 9:67–10:3; *Dec.*, ¶¶358-360; Claim 12, §§XVI.A-B (incorporated herein). A POSITA would have appreciated a *backside light trapping material* comprising a *metal layer* would be reflective against all wavelengths of light, whereas the “number of sub-layers in layer 204 and the materials used to form the sub-layers...produce a highly reflective DBR mirror at a **targeted wavelength**.” *Hong*, [0027]; *Dec.*, ¶358.

There would be a REOS at least because metal was a widely available material and because techniques for depositing a metal layer in an image sensor were very well-known. *Dec.*, ¶¶361-362; *cf.* '714 *Patent*, 8:6-9. The modification includes a simple substitution of one known element for another (a distributed Bragg reflector for a metal layer) to obtain predictable results (a pixel with backside material capable of reflecting unabsorbed photons back into the pixel). *Dec.*, ¶¶361-362.

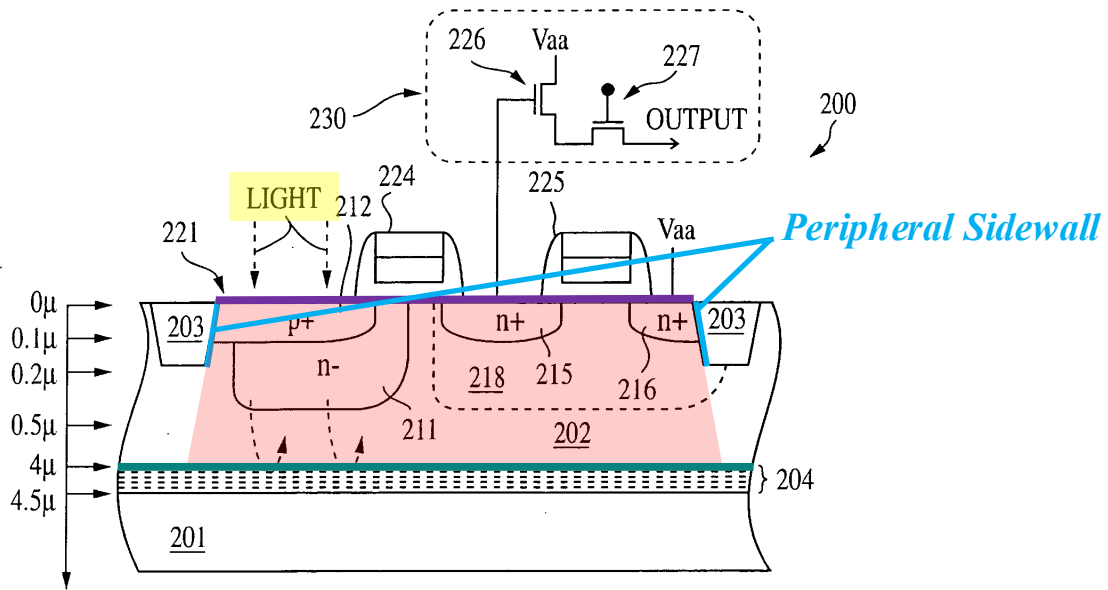
XVII. GROUND 13: CLAIM 16 IS OBVIOUS OVER HONG, YAMASHITA, HWANG-584, KONNO, AND KIM

See Claim 16, §X, mapping Kim's teachings (incorporated herein). In the combination, Hong modified to include Konno's window (*aperture*) is further modified that the window has an effective surface area of 90%, per Kim, and for similar motivations provided in §X, incorporated herein.

XVIII. GROUND 14: CLAIM 18 IS OBVIOUS OVER HONG, YAMASHITA, AND HWANG-584 IN COMBINATION WITH MOULI AND/OR NOZAKI

A. Hong's Sloped Trench Wall

Hong teaches a sloped trench wall; in the modified Hong combining Hwang-584's peripheral light trapping material, the material has a *sloped surface at the pixel device interface*:



Dec., ¶366; Claims 1[a][ii], 1[c], §§XII.A.4, XII.A.6 (incorporated herein).

B. Mouli's Sloped Trench Wall

To the extent SiOnyx contends Hong-Yamashita-Hwang-584 does not each Claim 18, Mouli also teaches sloped sidewalls, namely “high **conical** sidewalls....” *Mouli*, 5:16-18.

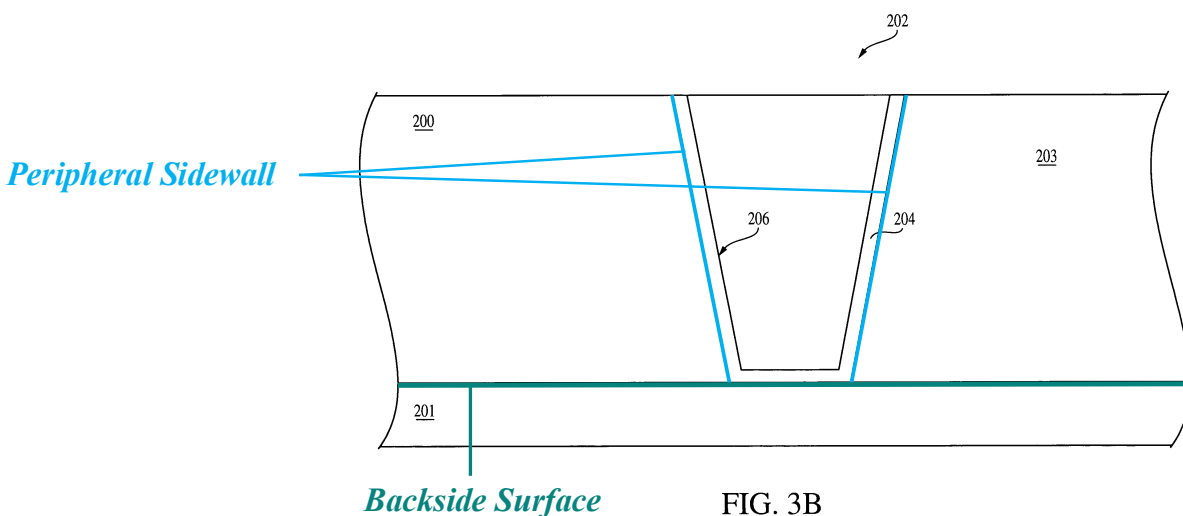


FIG. 3B

Dec., ¶368; §XI.A (incorporated herein);

For the reasons provided in §XI.A, a POSITA would have similarly been motivated to modify Hong to have sloped sidewalls, to the extent not otherwise taught in Hong, such that the peripheral light trapping material deposited on the sidewall, per the modification with Hwang-584, had a *sloped surface*. *Dec.*, ¶¶372-373.

C. Nozaki's Sloped Backside Surface

Regarding the *backside light trapping material* having a *sloped surface*, see Claim 18, §XI.B, mapping Nozaki's teachings and MTC/REOS (incorporated herein). For the reasons provided in §XI.B, a POSITA would have similarly been motivated to modify Hong's *backside light trapping material* (reflecting layer 204), to achieve "multiple angles of reflection...." *Nozaki*, [0027], [0019]; *Dec.*, ¶¶370-371.

The modification would have a REOS, at least because Hong already discloses a backside surface and methods for forming a backside light trapping material (layer 204; Claim 1[b], §XII.A.5), Nozaki teaches methods of forming the concave-shaped surface, and because methods of providing sloped backside surfaces in pixels were well-known. *Dec.*, ¶371; *Hong*, [0023]-[0025], [0030]-[0031]; *Nozaki*, [0034]-[0037].

D. Obviousness of Combining Both Mouli and Nozaki

Petitioner incorporates the MTC/REOS for Claim 18, §XI.C modifying both Hong’s backside surface (and commensurately, backside light trapping material on the backside surface) and peripheral sidewall (and commensurately, the peripheral light trapping material on the peripheral wall) to have a sloped surface, as the modification would have simply entailed combining the individual sloped surfaces and motivations discussed above, with the commensurate benefits and REOS. *Dec.*, ¶372-373.

XIX. DISCRETIONARY DENIAL

A. §314(a): General Plastic

The *General Plastic* (GP) factors weigh strongly against discretionary denial. *General Plastic Industrial Co., Ltd. v. Canon Kabushiki Kaisha*, IPR2016-01357, Paper 19, 9-10 (PTAB Sept. 6, 2017) (precedential).

1. Factor 1

GP factor one considers whether the “same petitioner previously filed a petition directed to the same claims of the same patent.” *General Plastic*, IPR2016-01357, Paper 19, 4. Factor 1 has been expanded to “consider any relation between those [different first and second] petitioners...[,]” i.e., a “significant relationship.” *Valve Corp. v. Elec. Scripting Prods., Inc.*, IPR2019-00062, Paper 11, 9-10 (PTAB Apr. 2, 2019) (precedential). Where “the first and second petitioners are neither the same party, nor possess a significant relationship...[,] factor one necessarily

outweighs the other *General Plastic* factors.” *Videndum Prod. Sols. v. Rotolight Ltd.*, IPR2023-01218, Paper 12, 6 (PTAB Apr. 19, 2024) (Director Written).

Samsung is challenging the ’714 Patent and is a first petitioner. *See* IPR2025-00161. This Petition is the first filed by current Petitioners, Apple/Sony, challenging the ’714 Patent. Each of the Board’s factors evaluating whether a significant relationship exists weighs in favor of no significant relationship between Apple/Sony and Samsung. Therefore, no further analysis of the GP factors is required, per *Videndum*.

No Coordination or Control: Apple/Sony began preparation of this IPR after Apple was sued by Patent Owner in September 2024. Apple/Sony have not had any involvement with Samsung in drafting this or the earlier Samsung IPR. *fubotv Media Inc. v. Dish Techs. L.L.C.*, IPR2024-00919, Paper 14, 27-28 (PTAB Nov. 21, 2024) (finding a petitioner’s un rebutted representation of noninvolvement in an earlier IPR did not suggest collusion or coordination). Apple/Sony filed this IPR independently of Samsung, and Apple/Sony are representing their own interests in pursuing this IPR. *Luminex Int’l Co. Ltd. v. Signify Holdings B.V.*, IPR2024-00101, Paper 20, 9 (PAB Nov. 21, 2024) (Director Written). Samsung had no control, input, funding, or direction of this IPR, and this IPR was not filed at Samsung’s behest. *Id.*

Not Co-Defendants: SiOnyx sued Apple for infringement of the ’714 Patent; SiOnyx has not sued Sony for infringement. *See* §XXI.B. Apple/Sony are not co-

defendants with Samsung in the same proceeding/forum. *Id.* The multiple petitions filed against the '714 Patent result from SiOnyx's litigation activity. *Sony Mobile Commc'ns Ab v. Ancora Techs., Inc.*, IPR2021-00663, Paper 17, 10-11 (PTAB June 10, 2021) (considering litigation activity against separate defendants as weighing against GP factor 1).

Petitioners Have an Independent Interest: Sony is a supplier of image sensors to both Samsung and Apple. SiOnyx accuses image sensors provided by both Samsung and Sony in the Samsung proceedings, whereas in the Apple litigation, SiOnyx only identifies a Sony sensor not at issue in the Samsung proceedings. (Exs. 1015, 1016 (Exhibits from Complaint in the Samsung district court litigation identifying Samsung-only sensors); Ex. 1065, pp. 1-2 (Samsung ITC action, *Joint Statement Identifying Accused Products*, identifying two Samsung and one Sony sensor); Ex. 1017, p. 1 (Exhibit from Complaint in the Apple litigation identifying Sony-only sensor). As a supplier of image sensors to litigants, Sony has a "strong and independent interest" in invalidating the '714 Patent. *Luminex*, IPR2024-00101, Paper 20, 14; *Samsung Elecs. Co., Ltd. v. Netlist, Inc.*, IPR2022-00615, Paper 20, 17-18 (PTAB Oct. 19, 2022). As a defendant in litigation accused of different products than Samsung and as a direct competitor of Samsung, Apple similarly has an independent interest in invalidating the '714 Patent. *Ford Motor Co. v. Neo Wireless LLC*, IPR2023-00763, Paper 28, 3 (PTAB Mar. 22, 2024) (holding "the

Board does not recognize a ‘significant relationship’ between parties having **different accused products** that merely engage in court-ordered pretrial coordination.”) (emphasis added); *Monolithic Power Sys., Inc. v. Greenthread LLC*, IPR2024-00551, Paper 26, 10 (PTAB Oct. 9, 2024).

No Exclusive Supplier Relationship: Sony is not an exclusive supplier of image sensors to either of Samsung or Apple. Sony supplies image sensors to multiple entities, such that Sony does not have an exclusive relationship with Samsung. A non-exclusive manufacturer-customer agreement alone does not establish a proxy relationship. *Luminex*, IPR2024-00101, Paper 20, 11; *WesternGeco LLC v. ION Geophysical Corp.*, 889 F.3d 1308, 1321-22 (Fed. Cir. 2018).

No Indemnification: Neither Sony nor Apple is indemnifying Samsung, either for the Samsung IPR or litigation. Regardless, creating an RPI/proxy relationship simply because of indemnification would have a “perverse result of encouraging patent owners to file infringement complaints against retailers to escape the threat of potential IPR challenges by manufacturers....” *Luminex*, IPR2024-00101, Paper 20, 12-13. The same analogy applies to the present facts, where customers Samsung and Apple were sued by SiOnyx, but supplier Sony was not.

No Roadmapping: The present IPR includes Grounds 8-14 applying art different than presented in the Samsung IPR. Additional Grounds 1-7 rely on

Hwang-099, applied in the Samsung IPR. However, this Petition maps a different Hwang-099 embodiment than the Samsung IPR and uses different secondary references to form entirely different combinations. §XIX.B.

Regardless, “the fact that the [earlier IPR] and instant IPR rely on similar references may merely result from the strength of references raised in the prior reexamination rather than copying from one petitioner to another.” *Signify North America Corp. v. CAO Lighting, Inc.*, IPR2023-00213, Paper 16, 23-24, n.13 (PTAB Jun. 15, 2023); *Apple Inc. v. Theta IP, LLC*, IPR2024-00819, Paper 12, 17 (PTAB Nov. 26, 2024); *Ascend Elements, Inc. v. Duesenfeld GmbH*, IPR2024-00948, Paper 10, 32-34 (PTAB Nov. 22, 2024).

Each of the above subfactors weighs against finding a significant relationship between Apple/Sony and Samsung. Consequently, GP Factor 1 is unmet, eliminating the need to rely on any further factors. However, should the Board be inclined to analyze the other GP factors, the remaining factors also weigh in favor of no discretionary denial of institution.

2. Additional General Plastic Factors

Regarding Factor 2, Petitioner Apple and Sony independently identified the primary reference Hwang-099 and had started preparing claim charts and this Petition before the Samsung IPR was filed; therefore, Factor 2 does not favor denial of institution, as Petitioner did not learn of the prior art from the Samsung IPR.

Factor 3 favors institution because PO has not filed a preliminary response, nor has the Board rendered an institution decision in the Samsung IPR.

Factors 4-5 favor institution, given Petitioners' diligence in filing. Petitioners began drafting this Petition after Apple was sued on September 12, 2024. This technology area is complex, and the available prior art is extensive. Petitioners have not located any case where six months was considered an undue delay in filing an IPR.

Factors 6-7 favor institution because the instant Petition respects the Board's finite resources and submits no redundant grounds (§XIX.B), and no roadblocks prevent a final determination within the statutory one-year limit. *Am. Honda Motor Co., Inc. v. Intellectual Ventures II*, IPR2018-00348, Paper 10, 19-20 (PTAB Jun. 27, 2018).

Factors 8-9 are applicable when a different petitioner files a subsequent petition. *Id.* at 20-21. Unlike in *Honda*, a denial here would prejudice the Petitioners. *Id.* Moreover, as in *Honda*, the filing of this Petition is the predictable direct result of SiOnyx's litigation activity. *Id.* at 20.

Because Petitioners lack a significant relationship with Samsung under Factor 1—and all remaining General Plastic factors favor institution—the Board should reach the merits on this Petition and institute review of the Challenged Claims.

B. §325(d): Advanced Bionics

Under *Advanced Bionics* and applying the *Becton Dickinson* factors, the Board should not deny institution under §325(d). Here, *Advanced Bionics*, Part 1, is not satisfied because the same or substantially the same art or arguments have not been “previously...presented to the Office[]” under 35 U.S.C. §325(d).

This Petition presents independent bases for unpatentability of all Challenged Claims not presented in, and materially different from, the Samsung IPR, namely Grounds 8-14 relying on, in part, the Hong-Yamashita-Hwang-584 combination. Additionally, Grounds 1-7 argue obviousness of Hwang-099’s Fig. 2 embodiment combined, in part, with the Fig. 6 embodiment, rather than the Samsung IPR’s obviousness of the Fig. 6 embodiment alone. *Cf.* §V, with Samsung IPR, Paper 1, 8. *Alivecor*, IPR2023-00950, Paper 12, 51 (considering reliance on different embodiments in finding no discretionary denial under §325(d)).

Additionally, the prior art references Hwang-099, Konno, and Kim are applied in the Samsung IPR, which has not reached a final decision on the merits and therefore, is not considered “previously...presented to the Office.” *Verizon Connect Inc. v. Omega Pats., LLC*, IPR2023-01162, Paper 12, 16-18 (PTAB Feb. 21, 2024) (non-final determinations in a previously filed IPR are “not a sufficient demonstration that the prior art raised therein was ‘previously presented’ so as to

satisfy *Becton Dickinson* or the statute.”); *Alivecor v. Apple*, IPR2023-00950, Paper 12, 51-54 (PTAB Jan. 9, 2024).

Regarding original examination, several of the applied references were cited in prior-issued related patents but not considered by the Examiner during examination of any of the related patents or the '714 Patent. Nor did the Examiner have the benefit of the combinations provided herein, further warranting no discretionary denial.

C. §314(a): *Fintiv*

The parallel Apple litigation is early. A scheduling conference was held and the Scheduling Order entered on February 28, 2025. No trial date is set. Discovery has just commenced, and the claim construction process has yet to begin, with a *Markman* hearing scheduled for November 2025, and summary judgment briefs due September 2026 at the earliest. (Ex. 1018, 1; Ex. 1019, 15-16). Under the local rules, a trial is due within 2 years of the initial scheduling conference, i.e., February 28, 2027. (Ex. 1020, 36). The *Fintiv* factors favor institution: (1) this IPR is filed soon after the Scheduling Order; (2) it is almost certain a Final Written Decision would precede a trial date given the entered case schedule; (3) there has been little to no investment in the litigation given the early stage, further indicating no overlap between issues in this IPR and the litigation; (4) Petitioner Sony is not a party to the Apple litigation and is not otherwise a party in any litigation proceeding; and (5) the

Petition indicates a high likelihood of unpatentability, including two separate grounds for unpatentability. Together, these factors strongly favor the Board declining discretionary denial.

XX. CONCLUSION

Petitioners respectfully request *inter partes* review of the Challenged Claims.

Respectfully submitted,

ERISE IP, P.A.

BY: /s/ Jennifer C. Bailey
Jennifer C. Bailey, Reg. No. 52,583

SMITH BUCHANAN

BY: /s/ Matthew A. Smith
Matthew A. Smith, Reg. No. 49,003

COUNSEL FOR PETITIONERS

XXI. MANDATORY NOTICES UNDER 37 C.F.R. § 42.8(A)(1)

A. Real Party-In-Interest

Petitioners Apple Inc. and Sony Group Corporation are the real parties-in-interest. 37 C.F.R. § 42.8(b)(1). The other real parties-in-interest are Sony Semiconductor Solutions Corporation, Sony Semiconductor Manufacturing Corporation, Sony Corporation, Sony Corporation of America, and Sony Electronics Inc.

B. Related Matters

1. District Court Litigation Matters

The '714 Patent is presently the subject of a patent infringement lawsuit filed against Petitioner Apple Inc.:

SiOnyx, LLC v. Apple Inc., No. 1:24-cv-12354 (D. Mass. Sept. 12, 2024).

Additionally, Patent Owner has filed the following district court action against third-party Samsung:

SiOnyx, LLC v. Samsung Elecs. Co., Ltd., No. 2:24-cv-00291 (E.D. Tex. Apr. 30, 2024).

2. ITC Matters

Patent Owner has filed the following ITC action against third-party Samsung:

In the Matter of Certain Sensors with Pixels and Products Containing the Same, USITC Inv., No. 337-TA-1403, Apr. 30, 2024.

3. *IPR Matters*

Third-party Samsung has filed the following IPR challenging Claims 1-18 of the '714 Patent:

Samsung Elecs. Co., Ltd. v. SiOnyx, LLC, IPR2025-00161 (PTAB Nov. 22, 2024) (the Samsung IPR).

C. **Lead and Back-Up Counsel**

Petitioners provide the following designation and service information for lead and back-up counsel. 37 C.F.R. §§ 42.8(b)(3) and (b)(4).

Lead Counsel	Back-Up Counsel
Jennifer C. Bailey (Reg. No. 52,583) jennifer.bailey@eriseip.com PTAB@eriseip.com <u>Postal and Hand-Delivery Address:</u> ERISE IP, P.A. 7015 College Blvd., Suite 700 Overland Park, Kansas 66211 Telephone: (913) 777-5600 Fax: (913) 777-5601 <i>Counsel for Petitioner Apple Inc.</i>	Matthew A. Smith (Reg. No. 49,003) smith@smithbaluch.com <u>Postal and Hand-Delivery Address:</u> SMITH BALUCH LLP 700 Pennsylvania Ave SE, Suite 2060 Washington, DC 20003 (202) 669-6207 <i>Counsel for Petitioner Sony Group Corporation</i>
	Callie A. Pendergrass (Reg. No. 63,949) callie.pendergrass@eriseip.com <u>Postal and Hand-Delivery Address:</u> ERISE IP, P.A. 7015 College Blvd., Suite 700 Overland Park, Kansas 66211 Telephone: (913) 777-5600 Fax: (913) 777-5601 <i>Counsel for Petitioner Apple Inc.</i>

D. 37 C.F.R. § 42.8(b)(4) – Service Information

Please address all correspondence to the lead and back-up counsel as shown above. Petitioners consent to electronic service by e-mail at the e-mail addresses provided above.

CLAIM LISTING APPENDIX
U.S. Patent No. 11,721,714 for Claims 1-18

Claim Designation	Claim Language
Claim 1[P]	1. A light trapping device , comprising:
Claim 1[a]	at least one light sensitive pixel
Claim 1[a][i]	having a light incident surface , a backside surface opposite the light incident surface, and
Claim 1[a][ii]	a peripheral sidewall disposed into at least a portion of the pixel and extending at least substantially around the pixel periphery;
Claim 1[b]	a backside light trapping material at least partially covering the backside surface ; and
Claim 1[c]	a peripheral light trapping material substantially covering the peripheral sidewall ;
Claim 1[d]	wherein light contacting the backside light trapping material or the peripheral light trapping material is reflected back toward the pixel ;
Claim 1[e]	wherein at least one of the backside light trapping material or the peripheral light trapping material includes a high refractive index material sandwiched between two low refractive index materials .
Claim 2	The device of claim 1, wherein the two low refractive index materials have a refractive index of less than about 2.1.
Claim 3	The device of claim 2, wherein at least one of the two low refractive index material includes a member selected from the group consisting of an oxide, a nitride, oxynitrides, a gas, at least a partial vacuum, and combinations thereof.
Claim 4	The device of claim 2, wherein the at least one of the two low refractive index materials includes a member selected from the group consisting of silicon oxide, silicon nitride, silicon dioxide, and combinations thereof.
Claim 5	The device of claim 1, wherein the high refractive index material includes a material having a refractive index of greater than or equal to about 2.1.

Claim Designation	Claim Language
Claim 6	The device of claim 5, wherein the high refractive index material includes a member selected from the group consisting of polycrystalline silicon, amorphous silicon, single crystal silicon, multicrystalline silicon, nanocrystalline silicon, germanium, and combinations thereof.
Claim 7	The device of claim 1, wherein at least one of the two low refractive index materials is doped with a dopant to create a surface field.
Claim 8	The device of claim 7, wherein the dopant is boron or antimony.
Claim 9	The device of claim 1, wherein at least one of the backside light trapping material and the peripheral light trapping material includes a first material sandwiched between two second materials, wherein the first material has a higher refractive index as compared to the two second materials, and wherein the difference in refractive index between the first material and the two second materials is at least 0.2.
Claim 10	The device of claim 1, wherein the peripheral sidewall extends completely around the pixel periphery.
Claim 11	The device of claim 1, wherein the peripheral sidewall extends from the light incident surface to the backside surface.
Claim 12	The device of claim 1, further comprising a frontside light trapping material at least partially covering the light incident surface.
Claim 13	The device of claim 12, wherein the frontside light trapping material is an antireflective layer coating.
Claim 14	The device of claim 12, wherein the frontside light trapping material is a reflective layer having an aperture to allow entry of light into the pixel, wherein the reflective layer is operable to reflect light impinging thereupon from inside the pixel back into the pixel.
Claim 15	The device of claim 14, further comprising a lens functionally coupled to the aperture and operable to focus incident light through the aperture and into the pixel.
Claim 16	The device of claim 14, wherein the aperture has an effective surface area of 90% of the incident light surface total surface area.

Claim Designation	Claim Language
Claim 17	The device of claim 1, wherein at least one of the backside light trapping material and the peripheral light trapping material is a metal layer .
Claim 18	The device of claim 1, wherein at least one of the backside light trapping material and the peripheral light trapping material has a sloped surface at the pixel device interface.

APPENDIX OF EXHIBITS

Exhibit 1001	U.S. Patent No. 11,721,714 (the “’714 Patent”)
Exhibit 1002	File History of the ’714 Patent (the “’714 File History”)
Exhibit 1003	Declaration of Dr. Stanley Shanfield (“Dec.”)
Exhibit 1004	U.S. Patent No. 7,675,099 to Hwang et al. (“Hwang-099”)
Exhibit 1005	U.S. Patent Publication No. 2010/0302432 to Komuro (“Komuro”)
Exhibit 1006	Certified English Translation of Korean Publication No. 2003-0001795 to Hwang (“Hwang-795”)
Exhibit 1007	U.S. Patent Publication No. 2011/0019050 to Yamashita (“Yamashita”)
Exhibit 1008	U.S. Patent No. 7,709,775 to Konno et al. (“Konno”)
Exhibit 1009	U.S. Patent Publication No. 2009/0160000 to Kim (“Kim”)
Exhibit 1010	U.S. Patent No. 7,492,027 to Mouli (“Mouli”)
Exhibit 1011	U.S. Patent Publication No. 2009/0194671 to Nozaki et al. (“Nozaki”)
Exhibit 1012	U.S. Patent Publication No. 2007/0108476 to Hong (“Hong”)
Exhibit 1013	Certified English Translation of Korean Patent No. 10-0688584 to Hwang (“Hwang-584”)
Exhibit 1014	<i>Certain Sensors with Pixels and Products Containing the Same</i> , Inv. No. 337-TA-1403, USITC Pub. 841145, (2025)
Exhibit 1015	<i>SiOnyx, LLC vs. Samsung Electronics, CO., LTD. et al.</i> , Case No. 2:24-cv-00291-JRG (EDTX, Dkt. No. 4-13)
Exhibit 1016	<i>SiOnyx, LLC vs. Samsung Electronics, CO., LTD. et al.</i> , Case No. 2:24-cv-00291-JRG (EDTX, Dkt. No. 4-14)
Exhibit 1017	<i>SiOnyx, LLC v. Apple, Inc.</i> , Case No. 1:24-cv-12354 (D. Mass, Dkt. No. 22-6)
Exhibit 1018	<i>SiOnyx, LLC v. Apple, Inc.</i> , Case No. 1:24-cv-12354 (D. Mass, Dkt. No. 53)
Exhibit 1019	<i>SiOnyx, LLC v. Apple, Inc.</i> , Case No. 1:24-cv-12354 (D. Mass, Dkt. No. 51)
Exhibit 1020	D. Mass Local Patent Rules
Exhibit 1021	S. M. Sze & Kwok Kwok Ng, <u>Physics of Semiconductor Devices</u> (3 rd ed. 2007) (“Sze”)
Exhibit 1022	James R. Janesick, <u>Scientific Charge-Coupled Devices</u> (2001) (“Janesick”)
Exhibit 1023	Alistair Sproul, <u>Solar Cells: Resources for the Secondary Science Teacher</u> , University of New South Wales (2003) (“Sproul”)
Exhibit 1024	U.S. Patent Publication No. 2007/0190681 to Lee et al. (“Lee”)

Exhibit 1025	R. Daniel McGrath, <i>Image Sensor Technology</i> , in <i>Single-Photon Imaging 27</i> (Peter Seitz & Albert JP Theuwissen eds., 2011) (“McGrath”)
Exhibit 1026	Christopher Shea, <i>A Silicon p-i-n detector for a hybrid CMOS imaging system</i> , Rochester Institute of Technology, https://repository.rit.edu/theses/7116 (2012) (“Shea”)
Exhibit 1027	<i>Photodiode Characteristics and Applications</i> , OSI Optoelectronics (2005) (“OSI Whitepaper”)
Exhibit 1028	H. A. Macleod, <i>Thin-Film Optical Filters</i> (3rd ed. 2001) (“Macleod”)
Exhibit 1029	Misha Boroditsky, Regina Ragan & Eli Yablonovitch, <i>Absorption Enhancement in Ultra-Thin Textured AlGaAs Films</i> , 57 <i>Solar Energy Materials and Solar Cells</i> 1 (1999) (“Boroditsky”)
Exhibit 1030	Jan Provoost and Piet De Moor, <i>Backside-illuminated image sensors: Optimizing manufacturing for a sensitivity payoff</i> , https://www.vision-systems.com/print/content/16744520 (2011, retrieved February 24, 2025) (“Provoost”)
Exhibit 1031	A. Tournier et al., <i>R 5 Pixel-to-Pixel Isolation by Deep Trench Technology: Application to CMOS Image Sensor</i> (2011) (“Tournier”)
Exhibit 1032	Vyshnavi Suntharalingam, Dennis D. Rathman, Gregory Prigozhin, Steven Kissel, and Mark Bautz, <i>Back-illuminated three-dimensionally integrated CMOS image sensors for scientific applications</i> , Proc. SPIE 6690, Focal Plane Arrays for Space Telescopes III, 669009 (2007) (“Suntharalingam”)
Exhibit 1033	U.S. Patent No. 6,888,214 to Mouli et al. (“Mouli-214”)
Exhibit 1034	Kyriaki Minoglou et al., <i>Reduction of Electrical Crosstalk in Hybrid Backside Illuminated CMOS Imagers Using Deep Trench Isolation</i> , in IEEE 2008 International Interconnect Technology Conference 129 (2008) (“Minoglou”)
Exhibit 1035	U.S. Patent No. 6,710,370 to Street et al. (“Street”)
Exhibit 1036	U.S. Patent Publication No. 2004/0251513 to Su et al. (“Su”)
Exhibit 1037	Maximillian A. Perez et al., <i>Rubidium Vapor Cell with Integrated Bragg Reflectors for Compact Atomic MEMS</i> , 154 <i>Sensors and Actuators A: Physical</i> 295 (2009) (“Perez”)
Exhibit 1038	I. H. Malitson, Interspecimen Comparison of the Refractive Index of Fused Silica*,†, <i>J. Opt. Soc. Am.</i> 55 (1965) (“Maltison”)
Exhibit 1039	U.S. Patent Publication No. 2011/0237060 to Lee et al. (“Lee-060”)

Exhibit 1040	U.S. Patent No. 7,824,983 to Juengling (“Juengling”)
Exhibit 1041	U.S. Patent No. 7,767,485 to Ogawa et al. (“Ogawa”)
Exhibit 1042	U.S. Patent Publication No. 2009/0091806 to Inuiya (“Inuiya”)
Exhibit 1043	U.S. Patent No. 7,911,006 to Chaudhry et al. (“Chaudhry-006”)
Exhibit 1044	U.S. Patent No. 7,595,213 to Kwon et al. (“Kwon”)
Exhibit 1045	U.S. Patent No. 7,141,836 to Adkisson et al. (“Adkisson”)
Exhibit 1046	U.S. Patent No. 7,491,610 to Chaudhry et al. (“Chaudhry-610”)
Exhibit 1047	M. Furumiya et al., <i>High-Sensitivity and No-Crosstalk Pixel Technology for Embedded CMOS Image Sensor</i> , 48 IEEE Transactions on Electron Devices 2221 (2001) (“Furumiya”)
Exhibit 1048	Yoshio Mita et al., <i>Deep-Trench Vertical Si Photodiodes for Improved Efficiency and Crosstalk</i> , 13 IEEE Journal of Selected Topics in Quantum Electronics 386 (2007) (“Mita”)
Exhibit 1049	U.S. Patent Publication No. 2010/0201834 to Maruyama et al. (“Maruyama”)
Exhibit 1050	U.S. Patent No. 6,730,896 to Yamada (“Yamada”)
Exhibit 1051	U.S. Patent Publication No. 2011/0083722 to Atwater et al. (“Atwater”)
Exhibit 1052	U.S. Patent No. 7,196,391 to Hsieh (“Hsieh”)
Exhibit 1053	U.S. Patent Publication No. 2008/0150054 to Kim (“Kim-054”)
Exhibit 1054	U.S. Patent Publication No. 2011/0005575 to Cao (“Cao”)
Exhibit 1055	U.S. Patent No. 6,809,008 to Holm et al. (“Holm”)
Exhibit 1056	U.S. Patent No. 6,033,968 to Sung (“Sung”)
Exhibit 1057	U.S. Patent No. 4,104,086 to Bondur et al. (“Bondur”)
Exhibit 1058	U.S. Patent No. 6,498,336 to Tian et al. (“Tian”)
Exhibit 1059	A. Crocherie, Jérôme Vaillant & F. Hirigoyen, <i>Three-Dimensional Broadband FDTD Optical Simulations of CMOS Image Sensor</i> , 29 Electronic Imaging (2008) (“Crocherie”)
Exhibit 1060	U.S. Patent No. 7,485,940 to Hsu et al. (“Hsu”)
Exhibit 1061	J. Michelot et al., <i>Back Illuminated Vertically Pinned Photodiode with in Depth Charge Storage</i> , INTERNATIONAL IMAGE SENSOR WORKSHOP (2011) (“Michelot”)
Exhibit 1062	U.S. Patent No. 7,800,192 to Venezia et al. (“Venezia”)
Exhibit 1063	U.S. Patent Publication No. 2008/0217720 to Fan et al. (“Fan”)
Exhibit 1064	U.S. Patent Publication No. 2008/0265349 to Kasano et al. (“Kasano”)
Exhibit 1065	Joint Statement Identifying Accused Products, <i>In the Matter of Certain Sensors with Pixels and Products Containing the Same</i> , USITC Inv., No. 337-TA-1403, Apr. 30, 2024

CERTIFICATION OF WORD COUNT

The undersigned certifies pursuant to 37 C.F.R. §42.24 that the foregoing Petition for *Inter Partes* Review, excluding any table of contents, mandatory notices under 37 C.F.R. §42.8, certificates of service or word count, or appendix of exhibits, contains 13,643 words according to the word-processing program used to prepare this document (Microsoft Word).

Dated: March 11, 2025

Respectfully submitted,

ERISE IP, P.A.

BY: /s/ Jennifer C. Bailey
Jennifer C. Bailey, Reg. No. 52,583

SMITH BUCHANAN

BY: /s/ Matthew A. Smith
Matthew A. Smith, Reg. No. 49,003

COUNSEL FOR PETITIONERS

**CERTIFICATE OF SERVICE ON PATENT OWNER
UNDER 37 C.F.R. § 42.105**

Pursuant to 37 C.F.R. §§ 42.6(e) and 42.105(b), the undersigned certifies that on March 11, 2025, a complete and entire copy of this Petition for *Inter Partes* Review and Exhibits were provided via Federal Express to the Patent Owner by serving the correspondence address of record for the '714 Patent:

Troutman Pepper Hamilton Sanders LLP (Rochester)
70 Linden Oaks
Suite 210
Rochester, NY 14625

Further, a courtesy copy of this Petition for *Inter Partes* Review was sent via email to Patent Owner's litigation counsel:

Pepper Hamilton
125 High Street, 19th Floor
Boston, MA 02110
Gwendolyn E. Tawresey (Gwendolyn.Tawresey@Troutman.com)
Gregory D. Len (leng@pepperlaw.com)
Ryan C. Deck (ryan.deck@troutman.com)
William D. Belanger (William.Belanger@Troutman.com)

Respectfully submitted,

ERISE IP, P.A.

BY: /s/ Jennifer C. Bailey
Jennifer C. Bailey, Reg. No. 52,583

SMITH BUCHANAN

BY: /s/ Matthew A. Smith
Matthew A. Smith, Reg. No. 49,003

