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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

HAMAMATSU CORPORATION,
Petitioner

v.

SIONYX, LLC,
Patent Owner

Case No. IPR2016-01910
U.S. Patent 8,680,591

PATENT OWNER'S NOTICE OF APPEAL TO THE U.S. COURT OF APPEALS FOR THE FEDERAL CIRCUIT

Pursuant to 35 U.S.C. §§ 141(c), 142, and 319 and 37 C.F.R. §§ 90.2, 90.3, and 104.2, Patent Owner SiOnyx, LLC ("Patent Owner") hereby provides notice of its appeal to the United States Court of Appeals for the Federal Circuit of the Final Written Decision (Paper 51) entered by the Patent Trial and Appeal Board ("PTAB") on March 28, 2018 (Attachment A), and from all underlying findings, orders, decisions, rulings and opinions. In particular, Patent Owner states that the issues to be addressed on appeal may include, but are not limited to:

A. Whether the PTAB erred in finding that claims 1, 7, 8, and 13 are unpatentable under 35 U.S.C. § 102 as being anticipated by United States Patent Application Publication No. 2007/0237504 (Ex. 1003, "*Nakashiba*")?

B. Whether the PTAB erred in finding that claims 1, 2, 4, 5, 7-11, 13-18, 21, and 23-25 are unpatentable under 35 U.S.C. § 103 as being obvious over United States Patent Application Publication US 2003/0029495 (Ex. 1005, *"Mazur"*) and United States Patent Application Publication No. 2003/0214595 (Ex. 1006, "*Mabuchi*")?

C. Whether the PTAB erred in finding that claim 6 is unpatentable under 35 U.S.C. § 103 as being obvious over *Mazur*, *Mabuchi*, and Japanese Patent Application JP H06-244444 (Ex. 1009, "*Uematsu*")?

Simultaneous with submission of this Notice of Appeal to the Director of the United States Patent and Trademark Office, this Notice of Appeal is being filed

with the Patent Trial and Appeal Board. In addition, this Notice of Appeal, along with the required docketing fees, is being filed with the United States Court of Appeals for the Federal Circuit.

Respectfully submitted,

Dated: May 24, 2018

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CERTIFICATE OF SERVICE

I hereby certify that on May 24, 2018, a true and accurate copy of this paper, PATENT OWNER'S NOTICE OF APPEAL TO THE U.S. COURT OF APPEALS FOR THE FEDERAL CIRCUIT, was served on counsel for Petitioner (John D. Simmons, Stephen E. Murray, and Keith A. Jones) via email:

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ATTACHMENT A

Trials@uspto.gov
571-272-7822

Paper No. 51
Entered: March 28, 2018

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

HAMAMATSU CORPORATION
Petitioner,

v.

SIONYX, LLC
Patent Owner.

Case IPR2016-01910
Patent 8,680,591 B2

Before GEORGIANNA W. BRADEN, MATTHEW R. CLEMENTS, and MONICA S. ULLAGADDI, *Administrative Patent Judges*.

Opinion for the Board filed by *Administrative Patent Judge* ULLAGADDI.

Opinion Concurring filed by *Administrative Patent Judge* CLEMENTS.

ULLAGADDI, *Administrative Patent Judge*.

FINAL WRITTEN DECISION
35 U.S.C. § 318(a) and 37 C.F.R. § 42.73

I. INTRODUCTION

A. Background

Hamamatsu Corporation ("Petitioner") filed a Petition (Paper 2, "Pet.") for *inter partes* review of claims 1–26 (the "challenged claims") of U.S. Patent No. 8,680,591 B2 (Ex. 1001, "the '591 patent") supported by Dr. Souri's Declaration (Ex. 1010). SiOnyx, LLC ("Patent Owner") timely filed a Preliminary Response (Paper 21, "Prelim. Resp.") supported by Mr. Guidash's Declaration (Ex. 2001). We instituted trial on claims 1, 2, 4–18, 21, and 23–26 of the '591 patent on certain grounds of unpatentability alleged in the Petition, but declined to institute trial on claims 3, 19, 20, and 22. Paper 22 ("Institution Decision" or "Inst. Dec.").

After institution of trial, Patent Owner filed a Request for Rehearing. Paper 24 ("Rehearing Request" or "Reh'g. Req."). In our Decision Granting-in-Part Patent Owner's Request for Rehearing under 37 C.F.R. § 42.71 (Paper 28, "Decision on Rehearing" or "Reh'g. Dec."), we granted-in-part Patent Owner's request as to claims 9, 24, and 25 and modified our Institution Decision to deny institution of claims 9, 24, and 25 for anticipation under 35 U.S.C. § 102 by Nakashiba. Reh'g. Dec. 7. We also modified the analysis in our Institution Decision to reflect the same. *Id*.

Patent Owner responded to Petitioner's challenges by filing a Patent Owner Response, along with Mr. Guidash's Second Declaration (Ex. 2003). Paper 29 ("PO Resp."). Petitioner timely filed a Reply, along with Dr. Souri's Second Declaration (Ex. 1014). Paper 32 ("Reply").

A hearing for IPR2016-01910 was held on October 4, 2017. The transcript of the hearing has been entered into the record. Paper 50 ("Tr.").

We have jurisdiction under 35 U.S.C. § 6. This final written decision is issued pursuant to 35 U.S.C. § 318(a).

Based on the complete record now before us, we conclude Petitioner has shown, by a preponderance of the evidence, that claims 1, 2, 4–11, 13–18, 21, and 23–25 of the '591 patent are unpatentable. We further conclude that Petitioner has failed to show, by a preponderance of the evidence, that claims 12 and 26 are unpatentable.

B. Related Proceedings

The parties inform us that the '591 patent is at issue in the following proceeding: *SiOnyx LLC, et al. v. Hamamatsu Photonics K.K., et al.*, 1:2015-cv-13488 (D. Mass.), which was originally filed on October 1, 2015. Pet. 1; Paper 20, 1.

C. The '591 Patent

The '591 patent is entitled "Photosensitive Imaging Devices and Associated Methods" and discloses a photosensitive pixel device including a semiconductor substrate with a textured region coupled thereto. Ex. 1001, [54], [57]. The textured region interacts with electromagnetic radiation by "increasing the semiconductor substrate's effective absorption wavelength as compared to a semiconductor substrate lacking a textured region." *Id.* at [57]. In Figure 10, reproduced below, textured region 90 is depicted as being adjacent to semiconductor substrate 72. *See id.* at 16:26–41.

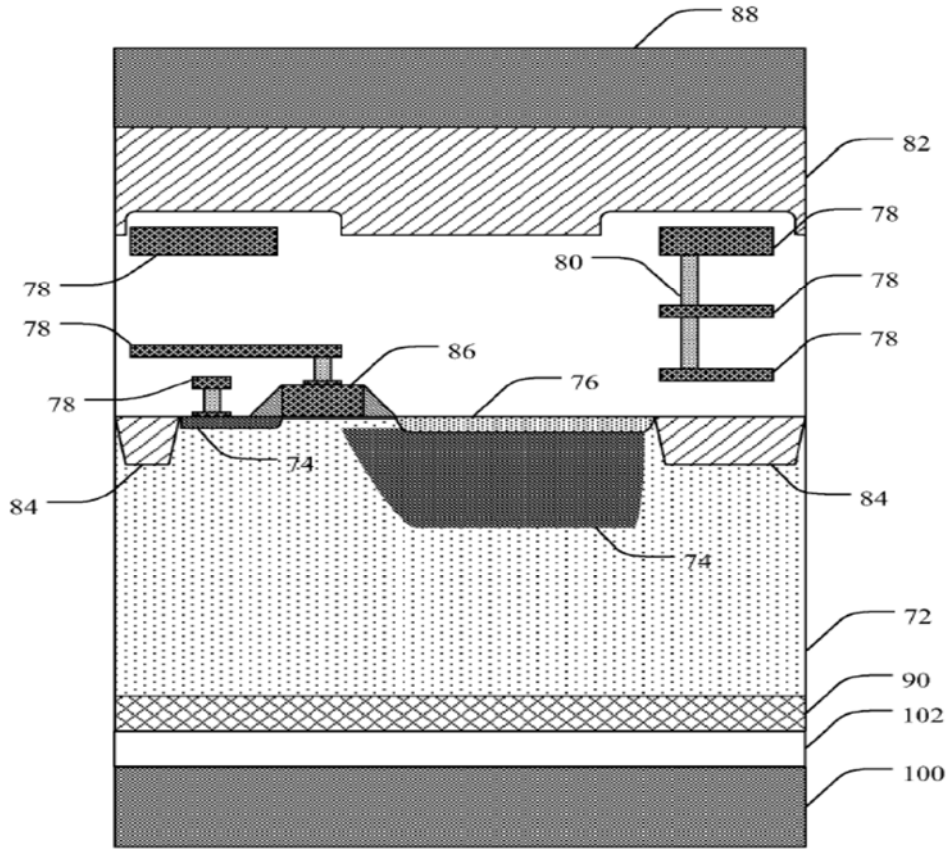


Figure 10 of the '591 patent is a schematic view of a photosensitive pixel device.

As shown in Figure 10, additional carrier support substrate 100 is coupled to the photosensitive pixel device on an opposing side from carrier support substrate 88. *Id.* at 16:26–28. Reflective layer 102 is disposed between textured region 90 and additional carrier support substrate 100. *See id.* at 16:32–33. The '591 patent discloses that "the configuration of the textured region can function to direct or focus electromagnetic radiation" into or away from the semiconductor substrate. *Id.* at 15:11–16. The '591 patent further discloses that the "location of the textured region can be used to provide enhancement and/or filtering of the incoming electromagnetic radiation." *Id.* at 14:41–43.

The photosensitive pixel device further includes metal regions 78, at least one via 80, passivation layer 82, trench isolation 84, and electrical transfer element

86. *Id.* at 15:55–57. The '591 patent discloses that "[t]rench isolation elements can maintain pixel to pixel uniformity by reducing optical and electrical crosstalk." *Id.* at 15:57–59.

D. Illustrative Claims

As noted above, Petitioner challenges claims 1–26 of the '591 patent, of which claims 1, 13, and 23 are independent. Independent claims 1 and 23 are reproduced below.

> 1. A photosensitive imager device, comprising:
> a semiconductor substrate having a substantially planar surface and multiple doped regions forming a least one junction;
> a textured region coupled to the semiconductor substrate on a surface opposite the substantially planar surface and positioned to interact with electromagnetic radiation;
> integrated circuitry formed at the substantially planar surface; and
> an electrical transfer element coupled to the semiconductor substrate and operable to transfer an electrical signal from the at least one junction.

Ex. 1001, 18:33–45.

> 23. A photosensitive imager device, comprising:
> a semiconductor substrate having a substantially planar surface and multiple doped regions forming a least one junction;
> a textured region coupled to the semiconductor substrate on a surface opposite the substantially planar surface and positioned to interact with electromagnetic radiation; and
> at least 4 transistors formed at the substantially planar surface with at least one of the transistors electrically coupled to the at least one junction.

Id. at 20:24–34.

E. The Instituted Grounds of Unpatentability

We instituted trial based on the following grounds and evidence of record:

Reference(s)	Basis	Claim(s) Challenged
Nakashiba[1]	§ 102	1, 4, 5, 7, 8, and 13
Mabuchi[2] and Mazur[3]	§ 103	1, 2, 4, 5, 7–11, 13–18, 21, and 23–26
Mabuchi, Mazur, and Uematsu[4]	§ 103	6
Mabuchi, Mazur, and Furukawa[5]	§ 103	12

Petitioner supports its challenges with the First and Second Declarations of Dr. Shukri J. Souri (Exs. 1010, 1014).

Patent Owner supports its Patent Owner Response with the Second Declaration of Mr. Michael Guidash (Ex. 2003).

II. DISCUSSION

A. Claim Construction

In an *inter partes* review, claim terms in an unexpired patent are interpreted according to their broadest reasonable construction in light of the specification of the patent in which they appear. 37 C.F.R. § 42.100(b); *Cuozzo Speed Techs., LLC v. Lee*, 136 S. Ct. 2131, 2144–46 (2016) (upholding the use of the broadest reasonable construction standard). Under that standard, and absent any special definitions, we generally give claim terms their ordinary and customary meaning, as would have been understood by one of ordinary skill in the art at the time of the invention. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007). An

[1] Ex. 1003, U.S. Patent Pub. No. 2007/0237504 A1 (Oct. 11, 2007) ("Nakashiba").
[2] Ex. 1006, U.S. Patent Pub. No. 2003/0214595 A1 (Nov. 20, 2003) ("Mabuchi").
[3] Ex. 1005, U.S. Patent Pub. No. 2003/0029495 A1 (Feb. 13, 2003) ("Mazur").
[4] Ex. 1009, English Translation of JP 06-94-244444 (Sept. 2, 1994) ("Uematsu"). The original publication in Japanese is Exhibit 1008.
[5] Ex. 1007, U.S. Patent Pub. No. 2006/0086956 A1 (Apr. 27, 2006) ("Furukawa").

inventor, however, may provide a meaning for a term that is different from its ordinary meaning by defining the term in the specification with "reasonable clarity, deliberateness, and precision." *In re Paulsen*, 30 F.3d 1475, 1480 (Fed. Cir. 1994). Limitations, however, are not to be read from the specification into the claims. *In re Van Geuns*, 988 F.2d 1181, 1184 (Fed. Cir. 1993). In addition, the Board may not "construe claims during [an *inter partes* review] so broadly that its constructions are *unreasonable* under general claim construction principles." *Microsoft Corp. v. Proxyconn, Inc.*, 789 F.3d 1292, 1298 (Fed. Cir. 2015). Claim terms need only be interpreted to the extent necessary to resolve the controversy. *See Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999).

1. "positioned to interact with electromagnetic radiation" (claims 1, 13, and 23)

Claims 1 and 23 recite that the textured region is "positioned to interact with electromagnetic radiation." Claim 13 similarly recites that the textured region is "formed in a position to interact with electromagnetic radiation." In its Preliminary Response, Patent Owner argued that these limitations require the claimed "textured region" to be "located to provide enhanced response to and/or filtering of electromagnetic radiation." Prelim. Resp. 11–12. In our Decision to Institute, we rejected that argument and determined instead that these limitations "encompass any positioning of the textured region in which the textured region can interact, in any way, with electromagnetic radiation." Inst. Dec. 9. Patent Owner requested rehearing, arguing that again the term should be construed to require "an enhanced response to and/or filtering of electromagnetic radiation." Paper 24, 5–9. In our Decision on Rehearing, we again rejected this argument because we were not persuaded that "interact with" required "provide enhanced response to and/or filtering of." Paper 28, 3–5.

In its Patent Owner Response, Patent Owner contends again that, under the broadest reasonable interpretation standard, these "position" limitations require the claimed "textured region" to be "located to provide enhanced response to and/or filtering of electromagnetic radiation." PO Resp. 8 (citing Ex. 2003 ¶ 34). Specifically, Patent Owner contends that the

> '591 Patent addresses the ineffectiveness of known silicon-based imagers in interacting with particular wavelengths of incident radiation by particularly and purposefully providing a silicon-based sensor (and photosensitive imager devices incorporating the same) that provides an enhanced response to and/or filtering of the radiation incident through the interaction of the textured surface with EMR [Electromagnetic Radiation].

PO Resp. 10 (citing Ex. 2003 ¶ 39). Patent Owner cites numerous portions of the '591 patent in support of this position. *See id.* at 11 (citing Ex. 1001, 1:42–48, 10:27–30, 10:38–39, 12:1–3; Ex. 2001 ¶¶ 35–37). Patent Owner argues that the disclosure of "facilitating the generation of an electrical signal" in the '591 patent "would have been understood by a person skilled in the art as enhancing the response to and/or filtering of radiation in a manner that addresses shortcomings of traditional silicon-based photodetecting imagers." *Id.* at 11–12 (citing Ex. 1001, 12:1–3; Ex. 2003 ¶¶ 30, 37).

Petitioner counters that the term "'[i]nteract' is also not used consistently in the '591 patent specification to refer to 'enhanced response' or 'filtering,'" and that "[t]he sections on which PO relies for support are merely narrowed example aspects separate from the more general aspect in which no restriction on the type or effect of interaction [is] found." Reply 2, 4.

We agree with Petitioner. The relevant case law does not support a conclusion in Patent Owner's favor. In *Liebel-Flarsheim Co. v. Medrad, Inc.*, 358 F.3d 898, 905–906 (Fed. Cir. 2004), Medrad argued that "because all the

embodiments described in the common specification of the . . . patents[-in-suit] feature pressure jackets, the claims of those patents must be construed as limited to devices that use pressure jackets." Like Patent Owner in the present proceeding, Medrad cited portions of the common specification describing an embodiment using a pressure jacket. *Id.* at 908. The Court found that, even though pressure jackets featured in all of the embodiments of the common specification, "the written description does not contain a clear disavowal of embodiments lacking a pressure jacket" and that the passages cited by Medrad fail to "expressly or by clear implication restrict the scope of the invention to injectors using a pressure jacket." *Id.*

Similarly, even if all of the embodiments disclosed in the '591 patent feature a textured region interacting with electromagnetic radiation in a manner that results in an enhanced response and/or filtering of the radiation, the embodiments do not *require* the textured region to provide this enhanced response and/or filtering and further, do not define the term "interaction" as an enhanced response or filtering. *See Liebel-Flarsheim*, 358 F.3d at 908 ("[T]he specification does not describe the invention as limited to embodiments having pressure jackets, and none of the other reasons that have been invoked for giving claims a narrow reading are present."). The claim language "interact with" is plainly broader than Patent Owner's proffered construction, and the "position" limitations can be read to encompass features not described in the written description. *See Liebel-Flarsheim*, 358 F.3d at 908 ("The fact that a patent asserts that an invention achieves several objectives does not require that each of the claims be construed as limited to structures that are capable of achieving all of the objectives.")

Moreover, the abstract of the '591 patent discloses that "[i]n one aspect, the textured region is operable to facilitate generation of an electrical signal from the

detection of infrared electromagnetic radiation," suggesting that at least in one aspect, "interact[ing] with" electromagnetic radiation includes merely generating electrons from photons. *See Liebel-Flarsheim*, 358 F.3d at 908 (noting that language from the abstract "can reasonably be understood as constituting a general description of the invention," and "does not suggest that a pressure jacket is an essential component of the invention," and further finding an absence of "language in that passage, or elsewhere in the specification, that disclaims the use of the invention in the absence of a pressure jacket").

In the Markman Memorandum and Order (Paper 44) from the co-pending district court litigation, the court found that

> [T]he specification provides examples where the textured region "interacts" with electromagnetic radiation in a number of different ways, including by "redirecting," "diffusing," "absorbing," and "filtering." The specification provides those forms of interaction as examples, and does not describe them as exhaustive. Therefore, even if the Court assumed that redirecting, diffusing, and absorbing radiation constituted "providing enhanced response," as plaintiffs suggest, the specification does not require that the claim is limited to those forms of interaction.

Paper 44, 31–32. Though not dispositive in reaching our conclusion here, the district court found "relevant and persuasive" our reasoning that "at least in one aspect, 'interact[ing] with' electromagnetic radiation includes merely generating electrons from photons, which is not an 'enhanced response' and/or 'filtering.'" *Id.* at 32 (quoting our Decision Denying-in-Part and Granting-in-Part Patent Owner's Request for Rehearing (Paper 28, 5)). The court further found that "[t]he specification does not use the term 'interact' to refer exclusively to 'enhanced response' or 'filtering' and therefore does not narrow the ordinary meaning of 'interact' to those functions." *Id.* Based on these findings, the district court

construed the "position" limitations to mean "located to receive and act upon electromagnetic radiation." *Id.* at 33.

Patent Owner also contends that our initial interpretation of the "position" limitations "would also encompass cases in which the textured region would have no effect on the photoelectric response of the photosensitive imager to the incident radiation, contrary to the purpose of the '591 Patent." PO Resp. 14-15. Patent Owner contends that "[t]his is so because the ordinary meaning of the term 'interact' is to '[] act in such a way to have an effect on another.'" *Id.* (citing Ex. 2011, 877; Ex. 2003 ¶ 40); *see id.* at 16. Patent Owner argues that

> In the absence of the textured region ***affecting*** the incident light in some way, a person skilled in the art would not conclude that the textured region has "interacted with" the incident light. In other words, a difference in the effect on the radiation with and without the textured region must be discernable in order to conclude that the textured region has interacted with incident light.

Id. at 15 (citing Ex. 2003 ¶ 40). Patent Owner urges us to construe the "position" limitations "to require that the textured region have an effect on electromagnetic radiation that would differ from that observed without such a textured region." *Id.* at 16 (citing Ex. 2003 ¶ 40).

We disagree that our construction encompasses cases in which the textured region is positioned to have no effect on electromagnetic radiation. Our construction requires the textured region to be positioned "to interact" and, as Patent Owner concedes, the ordinary meaning of "interact" is "to have an effect on another." PO Resp. 15. Although we have declined to limit that interaction to "enhanced response to and/or filtering" and have instead construed it to encompass interacting "in any way," we do not construe the limitation to encompass non-interaction. In any event, it is not necessary to make a final conclusion as to

whether these limitations encompass non-interaction because each of Nakashiba, Mabuchi, and Mazur discloses an interaction with electromagnetic radiation. *See Vivid Techs.*, 200 F.3d at 803.

Based on our review of the complete record and having considered the arguments and evidence adduced at trial, we maintain our determination that the "position" limitations encompass any positioning of the textured region in which the textured region can interact, in any way, with electromagnetic radiation.

2. "trench isolation" (claim 12)

Claim 12 recites "at least one trench isolation positioned between the at least two photosensitive imager device." In our Decision on Institution, we construed this term to mean "a channel that is formed by removing material from a semiconductor." Inst. Dec. 10.

Patent Owner does not dispute our construction and "applies the Board's initial construction of 'trench isolation' without prejudice." PO Resp. 16. Petitioner does not dispute our construction. *See generally* Pet. Reply *passim.*

Based on our review of the complete record and having considered the arguments and evidence adduced at trial, we maintain our initial decision and conclude "trench isolation" should be construed as "a channel that is formed by removing material from a semiconductor." *See* Inst. Dec. 10.

3. Limitations recited in claims 9, 24, and 25

In our Institution Decision, we determined that "claims 9, 24, and 25 recite product-by-process limitations that are not entitled to patentable weight" and thus, "for patentability purposes, it would not matter how, when, or by whom the composition was made." Inst. Dec. 12 (citing *In re Thorpe*, 777 F.2d 695, 697 (Fed. Cir. 1985)). We made this determination at the institution stage because

Petitioner's challenge based on anticipation by Nakashiba required a determination as to whether claims 9, 24, and 25 recited product-by-process limitations.

In our Decision on Rehearing, we granted-in-part Patent Owner's request to reconsider our Decision to Institute with respect to claims 9, 24, and 25. Reh'g. Dec. 7. We modified our Institution Decision to deny institution of trial with respect to claims 9, 24, and 25 for anticipation by Nakashiba. *Id.*

The only instituted challenge to claims 9, 24, and 25 that remains is based on obviousness over the combination of Mabuchi and Mazur. *Id.* at 8. As Petitioner's obviousness challenge relies on explicit disclosures in the references for teaching the claimed processes, it is not necessary to make a final conclusion as to whether claims 9, 24, and 25 recite product-by-process limitations to resolve the controversy before us. *See Vivid Techs.*, 200 F.3d at 803.

4. Preamble – "photosensitive imager device"

Although Patent Owner did not, in its Patent Owner Response, identify the preamble as requiring construction, Patent Owner argued during the hearing that the preamble is limiting—specifically that the claims "require an imager." *See* Tr. 26:25–27:19; 26:2–10. We consider whether the preamble is limiting because Patent Owner presents arguments premised on the claims requiring more than a single pixel device. *See generally* PO Resp. (presenting arguments regarding interactions and crosstalk between pixels in an imaging device). If the "imager" recited in the preamble of claims 1, 13, and 23 is considered limiting, then, according to Patent Owner, these claims would require a plurality of pixel devices because an imager must have more than a single pixel device to be capable of producing an image, which is constituted of more than a single pixel. In such case, Patent Owner's arguments would be commensurate in scope with the claims. If the "imager" recited in the preamble of claims 1, 13, and 23 is not considered

limiting, certain arguments presented by Patent Owner would not be commensurate in scope with the claims because the recitation of "at least one junction" in the body of independent claims 1, 13, and 23 encompasses a single junction, i.e., a single pixel device.

The district court found that "[t]he only way to give effect to every word in the claim term is to construe 'photosensitive imager device' to include that the device convert incident radiation into an image." Paper 44, 28. Although we are "not generally bound by a prior judicial construction of claim term," we acknowledge the district court's construction and "assess whether it is consistent with the broadest reasonable construction of the term." *Power Integrations, Inc. v. Lee*, 797 F.3d 1318, 1326 (Fed. Cir. 2015). For the reasons discussed below, we do not agree that the preamble should have a limiting effect.

The preamble may be construed as limiting "if it recites essential structure or steps, or if it is 'necessary to give life, meaning, and vitality' to the claim." *Catalina Mktg. Int'l, Inc. v. Coolsavings.com, Inc.*, 289 F.3d 801, 808 (Fed. Cir. 2002) (quoting *Pitney Bowes, Inc. v. Hewlett–Packard Co.*, 182 F.3d 1298, 1305 (Fed. Cir. 1999)). "A preamble is not regarded as limiting, however, 'when the claim body describes a structurally complete invention such that deletion of the preamble phrase does not affect the structure or steps of the claimed invention.'" *American Medical Sys., Inc. v. Biolitec, Inc.*, 618 F.3d 1354, 1358–59 (Fed. Cir. 2010) (quoting *Catalina*, 289 F.3d at 809). The Federal Circuit has "held that the preamble has no separate limiting effect if, for example, 'the preamble merely gives a descriptive name to the set of limitations in the body of the claim that completely set forth the invention.'" *Id.* at 1359 (quoting *IMS Tech., Inc. v. Haas Automation, Inc.*, 206 F.3d 1422, 1434–35 (Fed. Cir. 2000)).

In this case, the term "photosensitive" is descriptive of the "semiconductor substrate" recited in claims 1, 13, and 23. None of claims 1, 13, and 23 recite an image or generating an image. Accordingly, the preamble "[a] photosensitive imager device" recited in claims 1 and 23 does not affect the structure of the invention recited in the body of claims 1 and 23, respectively. Similarly, the preamble "[a] method of making a photosensitive imager device" recited in claim 13 does not affect the steps of the invention recited in claim 13.

Figures 1–6 of the '591 patent illustrate "photosensitive devices" according to aspects of the invention, Figures 7–13, 15, and 16 illustrate "photosensitive pixel devices" according to aspects of the invention, Figure 14 illustrates a "photosensitive imager device," and Figure 17 illustrates a "method of making a photosensitive imager device." Thus, the '591 patent specification discloses aspects in which an imager can, not must, be part of the invention, and that the "semiconductor substrate," "textured region," "integrated circuitry," and "at least one transfer element" need not be incorporated in a "photosensitive imager device." Furthermore, the prosecution history indicates that the preambles formed the basis of the originally submitted independent claims–the preambles recited in claims 1, 13, and 23 were not added to distinguish the claimed inventions from the prior art. *See generally* Ex. 1002.

For the reasons discussed above, we conclude the preambles of independent claims 1, 13, and 23 are not entitled to patentable weight.

B. Principles of Law

"A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." *Verdegaal Bros., Inc. v. Union Oil Co. of California*, 814 F.2d 628, 631 (Fed. Cir. 1987).

A claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations, including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of skill in the art; and (4) objective evidence of nonobviousness, i.e., secondary considerations. *See Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

"In an [*inter partes* review], the petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable." *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir. 2016) (citing 35 U.S.C. § 312(a)(3) (requiring *inter partes* review petitions to identify "with particularity . . . the evidence that supports the grounds for the challenge to each claim")). This burden never shifts to Patent Owner. *See Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015) (citing *Tech. Licensing Corp. v. Videotek, Inc.*, 545 F.3d 1316, 1326–27 (Fed. Cir. 2008)) (discussing the burden of proof in *inter partes* review). Furthermore, Petitioner cannot satisfy its burden of proving obviousness by employing "mere conclusory statements." *In re Magnum Oil Tools Int'l, Ltd.*, 829 F.3d 1364, 1380 (Fed. Cir. 2016).

Thus, to prevail in an *inter partes* review, Petitioner must explain how the prior art anticipates the challenged claims and how the proposed combinations of prior art would have rendered the challenged claims unpatentable. We analyze the challenges presented in the Petition in accordance with the above-stated principles.

C. Level of Ordinary Skill in the Art

In determining whether an invention would have been obvious at the time it was made, we consider the level of ordinary skill in the pertinent art at the time of the invention. *Graham*, 383 U.S. at 17. "The importance of resolving the level of ordinary skill in the art lies in the necessity of maintaining objectivity in the obviousness inquiry." *Ryko Mfg. Co. v. Nu-Star, Inc.*, 950 F.2d 714, 718 (Fed. Cir. 1991).

Petitioner's declarant, Dr. Souri, testifies that a person of ordinary skill in the art relevant to the '591 patent "would hold a bachelor's degree in physics, electrical engineering, or a related discipline, and have at least one year of experience working in the field of semiconductor processing or optoelectronic device design." Ex. 1010 ¶ 32; Pet. 8. Patent Owner applies Petitioner's proposed level of ordinary skill in the art for purposes of this proceeding. PO Resp. 7 n.2.

Based on our review of the '591 patent, the types of problems and solutions described in the '591 patent and cited prior art, the testimony of Petitioner's and Patent Owner's declarants, and the arguments and evidence adduced at trial, we agree with and apply Petitioner's definition of a person of ordinary skill in the art at the time of the claimed invention. *See* Inst. Dec. 14–15.

D. Asserted Challenge Based on Nakashiba

Petitioner contends claims 1, 4, 5, 7, 8, and 13, are anticipated under 35 U.S.C. § 102 by Nakashiba. Pet. 18–25. Patent Owner disputes Petitioner's contentions. PO Resp. 17–25. The burden, however, remains on Petitioner to demonstrate unpatentability. *See Dynamic Drinkware*, 800 F.3d at 1378. For the reasons that follow, we find Petitioner has demonstrated by a preponderance of the evidence that claims 1, 7, 8, and 13 are anticipated by Nakashiba. We find,

however, Petitioner has failed to demonstrate by a preponderance of the evidence that claims 4 and 5 are anticipated by Nakashiba.

1. Overview of Nakashiba

Nakashiba is entitled "Solid State Imaging Device" and discloses a semiconductor substrate having a rough contact surface as its back surface. Ex. 1003, [54], [57]. Figure 3, reproduced below, illustrates solid-state image device 1, which images fingerprint 92, and includes contact surface S1. *Id.* ¶ 28.

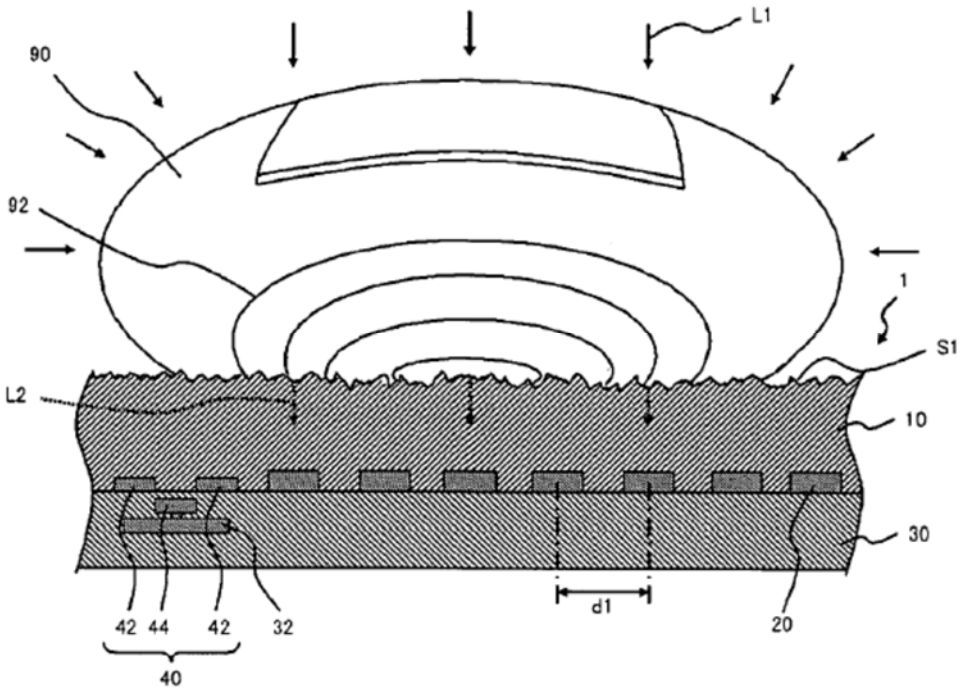


Figure 3 of Nakashiba is a cross-sectional view of solid-state imaging device 1, finger 90, and fingerprint 92.

In Figure 3, solid-state imaging device 1 is shown as including semiconductor substrate 10, light receiving portions 20, interconnect layer 30 including interconnect 32, and MOSFET [Metal Oxide Semiconductor Field Effect Transistor] 40 including N-type impurity diffusion layer 42 and gate electrode 44. *Id.* ¶¶ 19, 22, 23. Semiconductor substrate 10 is a P-type silicon substrate and

includes contact surface S1, which has "undergone a roughening process such as a non-glass processing or mat finishing . . . executed by a surface treatment process such as mechanical polishing." *Id.* ¶¶ 19, 20.

When finger 90 is brought into contact with contact surface S1 and light L1 from a light source is incident upon finger 90, transmitted light L2 is photoelectrically converted in semiconductor substrate 10. *Id.* ¶ 28. Nakashiba discloses that "light receiving portions 20 receive the signal charge generated by the photoelectric conversion, to thereby acquire an image of the fingerprint 92." *Id.* Nakashiba further discloses that "light L1 may be visible light, near-infrared light or infrared light." *Id.*

In Nakashiba, because contact surface S1 is roughened, "after the finger, which is the object to be imaged, is brought into direct contact with the contact surface S1, the residual fingerprint barely remains on the contact surface S1, unlike in the case where the contact surface S1 is smooth." *Id.* ¶ 30.

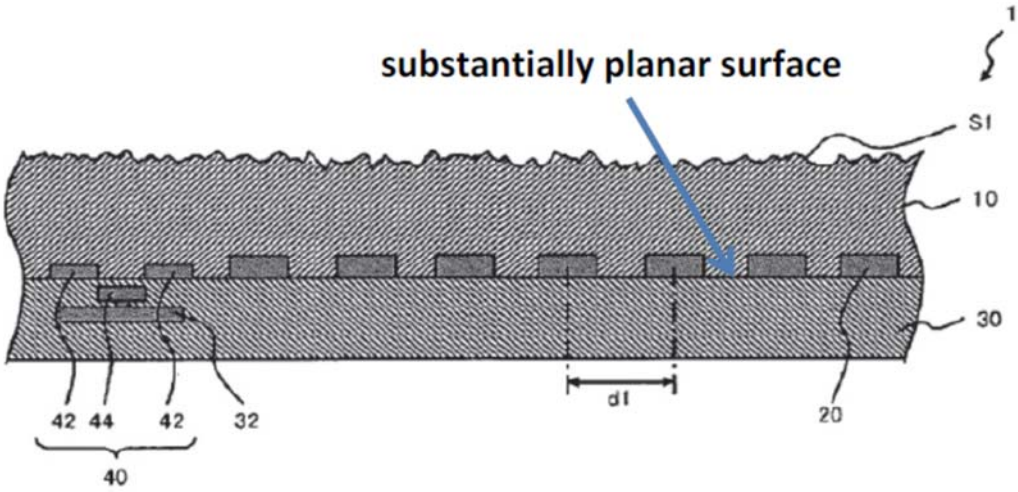
2. Analysis

a. Independent Claim 1

(1) "[a] photosensitive imager device, comprising: a semiconductor substrate having a substantially planar surface and multiple doped regions forming a least one junction"

According to Petitioner, "Nakashiba's solid-state imaging device 1 is a photosensitive imager device comprising a semiconductor substrate 10 with a substantially planar surface (the surface opposite to contact surface S1)." Pet. 18. Petitioner further contends "[t]he plurality of N-type impurity light receiving portions 20 form at least one junction with the p-type profile of the silicon substrate 10." *Id.* at 18–19 (citing Ex. 1003, Fig. 1, ¶¶ 19, 21; Ex. 1010 ¶¶ 89, 90).

Reproduced below is an annotated version of Nakashiba's Figure 1, with an arrow added by Petitioner to designate the claimed "substantially planar surface."



Petitioner's annotated version of Figure 1 of Nakashiba depicts a solid-state imaging device and substantially planar surface.

Patent Owner does not provide specific arguments regarding Petitioner's contentions for this limitation.[6] Having considered the question of patentability anew based on our review of the complete record, we find that Nakashiba's P-type silicon semiconductor substrate 10 corresponds to the claimed "semiconductor substrate having a substantially planar surface." *See e.g.*, Pet. 18–19 (citing Ex. 1003, Fig. 1, ¶¶ 19, 21; Ex. 1010 ¶¶ 89, 90). We further find that Nakashiba's plurality of n-type impurity light receiving portions 20 that form at least one junction with the p-type profile of silicon substrate 10 corresponds to the claimed "multiple doped regions forming at least one junction." *See id*.

[6] The burden, however, remains on Petitioner to demonstrate unpatentability. *See Dynamic Drinkware*, 800 F.3d at 1378.

> *(2) "a textured region coupled to the semiconductor substrate on a surface opposite the substantially planar surface and positioned to interact with electromagnetic radiation"*

According to Petitioner, "[w]hile provided for a different purpose than enhancing light absorption, Nakashiba also includes a roughened (textured) contact surface S1 coupled to the silicon substrate 10 that interacts with electromagnetic radiation in the form of light L2 transmitted by the object to be imaged." Pet. 20 (citing Ex. 1003 ¶¶ 19, 20, 22, 26, 28, Figs. 1, 2; Ex. 1010 ¶¶ 92–94).

Patent Owner disputes Petitioner's position, contending that "*Nakashiba*'s objective in providing the roughened contact surface (S1) is wholly unrelated to the purpose and effect of the textured regions disclosed by the '591 Patent, and that this roughened contact surface (S1) also does not necessarily provide any enhanced response to or filtering of the source light (L1), as would be recognized by a person of ordinary skill in the art." PO Resp. 21 (citing Ex. 2003 ¶ 51; *In re Robertson*, 169 F.3d 743, 745 (Fed. Cir. 1999)).

We note initially that Nakashiba's objective for providing a textured surface is not relevant to establishing a successful challenge under the legal doctrine of anticipation. *See Kalman v. Kimberly–Clark Corp.,* 713 F.2d 760, 772 (Fed. Cir. 1983) ("The law of anticipation does not require that the reference 'teach' what the subject [matter of the] patent teaches . . . it is only necessary that the claims under attack, as construed by the court, 'read on' something disclosed in the reference."), *overruled in part on other grounds, SRI Int'l v. Matsushita Elec. Corp. of Am.*, 775 F.2d 1107, 1125 (Fed. Cir. 1985) (en banc). Furthermore, as we explained *supra* § II.A.1, the "position" limitation recited in claim 1 does not require any enhanced response or filtering under the broadest reasonable interpretation, contrary to Patent Owner's contention. The "position" limitation encompasses "any

positioning of the textured region in which the textured region can interact, in any way, on electromagnetic radiation," as discussed above. *Supra* § II.A.1.

Patent Owner also contends that "there is no indication in *Nakashiba* of any difference on the incident radiation with and without . . . *Nakashiba*'s contact surface being roughened." PO Resp. 24 (citing Ex. 2003 ¶ 51).

This argument is not persuasive because Patent Owner takes the position that any effect on source light L1 is not shown to be *solely* due to Nakashiba's roughened contact surface S1. *See* PO Resp. 24. This is an implicit claim construction argument based on Patent Owner's proffered construction, which we did not adopt. *Supra* § II.A.1. Neither the "position" limitation nor claim 1 as a whole is so limited so as to require an effect that results *only* from the "textured region." Rather, claim 1 encompasses an effect resulting from a combination of the claimed "textured region" and the underlying "semiconductor substrate."

Patent Owner further contends that "Petitioner has failed to present any evidence at all that Nakashiba's roughened contact surface (S1) has any effect on the light passing through it." *Id.* at 21 (citing Ex. 2003 ¶ 52). Specifically, Patent Owner argues that "the contact surface (S1) would . . . present an essentially planar surface to the source light (L1)," which "would fail to cause any appreciable refraction or diffusion of the incident light." *Id.* at 21–22 (citing Ex. 2003 ¶¶ 50, 51); *see id.* at 23 ("Petitioner [has] provided no evidence that the mere passage of light through the roughened surface of *Nakashiba* effects the light in any discernable way.").

We do not agree with Patent Owner that Petitioner has failed to demonstrate sufficiently that Nakashiba's roughened contact surface S1 affects incident light. Even assuming, *arguendo*, we were to agree with Patent Owner's argument that Nakashiba's contact surface S1 presents an essentially planar surface, we disagree

that it would not affect incident light.[7] We agree with Petitioner that Nakashiba's "contact surface S1 is exposed to air, which has a refractive index of about 1, and is formed on a silicon substrate, which has an index of refraction between 3.5-6.5, depending on the wavelength of light," and "[t]hus, there will be an interaction (reflection and/or refraction) with [incident] light at the contact surface S1." Reply 6 (citing Ex. 1014 ¶¶ 30, 31); *see id.* at 7. We credit the testimony of Dr. Souri, who testifies as to differences in the refractive indices of air, silicon, and a finger, and that, when there is a change in refractive index between materials, there is an interaction with light. *See* Ex. 2012, 119:22–121:16. Dr. Souri further testifies that

> [W]hen light is incident upon a boundary between materials of different refractive index, both refraction and reflection occur, as is depicted in the diagram above. The fraction of incident light that is refracted, and the fraction which is reflected, may be calculated by Fresnel's equations, using the angles of incidence and refraction given by Snell's law.
>
> . . .
>
> [A] person of ordinary skill in the art would understand that these reflection and refraction effects constitute an interaction with electromagnetic radiation; and, consequently, said person would understand that the roughened surface S1 of Nakashiba satisfies the requirements of the term "interact" as used in the claims of the '591 patent.

Ex. 1014 ¶¶ 27, 28. Although discussing the challenge over Mabuchi and Mazur, Patent Owner's declarant similarly testifies that

[7] Patent Owner argues that roughened contact surface S1 would "fail to cause any appreciable refraction or diffusion" of wavelengths of *source light L1*. PO Resp. 24.

> [T]he interface between two materials (*e.g.*, air and the textured silicon) would cause optical scattering by refraction or reflection depending, for example, on the angle of incidence upon the surface and the materials' indices of refraction. The relationship between the angle of incidence and the angle of refraction is governed by Snell's law.

Ex. 2003 ¶ 68 (citing Jackson, J.D., *Classical Electrodynamics*, John Wiley & Sons, Inc.; 2d. Edition (1975), pp. 278–79 (Ex. 2005, "Jackson")); PO Resp. 35.

Finally, we do not agree with Patent Owner that roughened contact surface S1 would "fail to cause any appreciable refraction or diffusion" of wavelengths of *source light L1* because the claims do not require the textured region to be positioned to interact with any particular wavelengths of electromagnetic radiation. *See* PO Resp. 24.

Having considered the question of patentability anew based on our review of the complete record, we find that Nakashiba's roughened contact surface S1 interacts with incident light and, therefore, discloses the claimed "textured region" as recited in claim 1. *See e.g.,* Pet. 20 (citing Ex. 1003 ¶¶ 19, 20, 22, 26, 28, Figs. 1, 2; Ex. 1010 ¶¶ 92–94).

(3) "integrated circuitry formed at the substantially planar surface"

According to Petitioner, "Nakashiba's solid-state imaging device 1 further comprises integrated circuitry in the form of, for example, the MOSFET 40 formed at the substrate's 10 planar surface." Pet. 19 (citing Ex. 1003 ¶ 22, Fig. 1; Ex. 1010 ¶ 96). Patent Owner does not provide specific arguments regarding Petitioner's contentions for this limitation. *See supra* at fn.6.

Having considered the question of patentability anew based on our review of the complete record, we find that Nakashiba's MOSFET 40, which includes N-type

impurity diffusion layer 42 and gate electrode 44, is formed at the substantially planar surface of silicon substrate 10 and discloses the claimed "integrated circuity" as recited in claim 1. *See, e.g.*, Pet. 19 (citing Ex. 1003 ¶ 22, Fig. 1; Ex. 1010 ¶ 96).

> *(4) "an electrical transfer element coupled to the semiconductor substrate and operable to transfer an electrical signal from the at least one junction"*

According to Petitioner, "[w]hile Nakashiba does not explicitly teach an electrical transfer element coupled to the substrate and operable to transfer an electrical signal from the junction, one of ordinary skill in the art would recognize that this element is necessarily present." Pet. 19 (citing Ex. 1003 ¶¶ 22, 28; Ex. 1010 ¶¶ 99–101). Patent Owner does not provide specific arguments regarding Petitioner's contentions for this limitation. *See supra* at fn.6.

If a prior art reference does not expressly set forth a particular element of the claim, the reference still may anticipate only if that element is "inherent" in its disclosure. *Trintec Indus., Inc. v. Top-U.S.A. Corp.*, 295 F.3d 1292, 1295 (Fed. Cir. 2002). The Federal Circuit has held that

> To establish inherency, the extrinsic evidence must make clear that the missing descriptive matter is *necessarily* present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill. Inherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient.

Robertson, 169 F.3d at 745 (citations and internal quotations omitted) (emphasis added).

With regard to inherent disclosure, Petitioner contends that

> Nakashiba teaches that incident light is photoelectrically converted in the substrate 10 and the light receiving portions 20 receive a signal charge generated thereby, which is used to acquire the image of a fingerprint. (Ex. 1003 at [0028]; Ex. 1010 at ¶ 99). The charge stored in the light receiving portions must be read out to acquire the image. Moreover, the fingerprint images are encoded in the spatial distribution of the light receiving portions 20. To maintain contrast in the image features, the spatial charge distribution must be preserved, meaning that the charge in each light receiving portion 20 must be individually readable. (Ex. 1003 at [0022]; Ex. 1010 at ¶¶ 100-101). One of ordinary skill in the art therefore understands that a transfer element must be coupled to the substrate at each pixel in order to facilitate the image acquisition described in Nakashiba. (Ex. 1010 at ¶ 101). Indeed, such transfer elements are commonly known for photosensitive semiconductor devices. (Ex. 1010 at ¶ 97).

Pet. 19–20. The evidence supports Petitioner's contention and we agree that charge must necessarily be transferred from light receiving portions 20 to create an image signal, e.g., via the disclosed MOS image sensor unit. *Id.* (citing Ex. 1003 ¶¶ 22, 28; Ex. 1010 ¶¶ 97, 99–101).

Having considered the question of patentability anew based on our review of the complete record, we find that Nakashiba discloses inherently the "electrical transfer element" as recited in claim 1. *Id.* In view of the above, we find that Nakashiba discloses the limitations recited in claim 1 as arranged in the claim, as Petitioner establishes by a preponderance of the evidence. *See id.* at 18–22 (citing Ex. 1003 ¶¶ 19–22, 26, 28, Figs. 1, 2; Ex. 1010 ¶¶ 89–103).

b. Independent Claim 13

Claim 13 recites features substantially similar to those recited in claim 1. We find that Petitioner's arguments and evidence presented with respect to claim 1

also are persuasive with respect to claim 13 for substantially similar reasons. *See* Pet. 24–25 (citing Ex. 1010 ¶¶ 112–16); *see id.* at 18–22 (citing Ex. 1003 ¶¶ 19–22, 26, 28, Figs. 1, 2; Ex. 1010 ¶¶ 89–103). Patent Owner's arguments for claim 13 are the same as those for claim 1. PO Resp. 19–25. Accordingly, our analysis with respect to claim 1 is substantially applicable to claim 13. *See supra* § II.D.2.a. Having considered the question of patentability anew based on our review of the complete record, we find that Nakashiba discloses the limitations recited in claim 13 as arranged in the claim, as Petitioner establishes by a preponderance of the evidence. *See* Pet. 24–25 (citing Ex. 1010 ¶¶ 112–16); *see id.* at 18–22 (citing Ex. 1003 ¶¶ 19–22, 26, 28, Figs. 1, 2; Ex. 1010 ¶¶ 89–103).

c. Dependent Claims 4, 5, 7, and 8

Claim 4 recites, *inter alia*, "wherein the textured region has a surface morphology operable to direct electromagnetic radiation into or out of the semiconductor substrate." Claim 4 depends from claim 1. Petitioner contends that "[t]he roughening exhibits a morphology that is operable to direct the light L2 *into* the substrate 10, since it is provided at the light receiving contact surface S1." Pet. 20 (emphasis added). Petitioner does not cite a portion of Nakashiba that discloses expressly the surface morphology's role in directing incident light into substrate 10, whether considered independently of or in conjunction with the underlying silicon substrate. *See id.* Therefore, we understand Petitioner's position to be based on the theory of inherency.

As discussed above with respect to claim 1, Petitioner demonstrates that roughened contact surface S1 "interacts with" incident light at least via refraction because the incident light passes through two materials (e.g., air and silicon) having different indices of refraction. *See supra* § II.D.2.a. Petitioner's challenge does not persuade us, by a preponderance of the evidence, that it is the *surface*

morphology that necessarily directs at least some of the incident light into the semiconductor substrate. Petitioner's challenge leaves open the possibility that: (1) it is only the differences in indices of refraction that affects the path of incident light; as well as the possibility that (2) the path of incident light is not affected or changed at all, for example, when it is perpendicularly incident on roughened contact surface S1 and thus, is not "*directed into* . . . the semiconductor substrate." In view of the above, the arguments and evidence presented by Petitioner do not support, by a preponderance of the evidence, the finding that Nakashiba discloses, expressly or inherently, "the textured region has a surface morphology operable to direct electromagnetic radiation into . . . the semiconductor substrate," as recited in claim 4, contrary to Petitioner's contention. *See* Pet. 20.

Claim 5 recites, *inter alia*, "wherein the surface morphology of the textured region relative to the semiconductor substrate is a member selected from the group consisting of sloping, pyramidal, inverted pyramidal, spherical, parabolic, asymmetric, symmetric, and combinations thereof." Claim 5 depends from claim 4. At least because Petitioner fails to establish that Nakashiba discloses the limitation recited in claim 4, Petitioner also fails to establish that Nakashiba discloses the limitation recited in claim 5.

Claim 7 recites, *inter alia*, "wherein the textured region includes surface features having a size selected from the group consisting of micron-sized, nano-sized, and combinations thereof." Claim 7 depends from claim 1. We find that Nakashiba supports Petitioner's position that the reference discloses a textured region with micron-sized surface features because Nakashiba discloses that the "average arrangement pitch of the concave and convex portions of the contact surface S1" may be approximately 0.1 to 10 μm or 50 μm. *See* Pet. 23–24 (citing Ex. 1003 ¶ 26; Ex. 1010 ¶¶ 109, 110). Having considered the question of

patentability anew based on our review of the complete record, we find that Nakashiba discloses the limitation recited in claim 7, as Petitioner establishes by a preponderance of the evidence. *See id.*

Claim 8 recites, *inter alia,* "wherein surface features include a member selected from the group consisting of cones, pillars, pyramids, micolenses, quantum dots, inverted features, and combinations thereof." Claim 8 depends from claim 7. Petitioner cites Figure 2 of Nakashiba, which illustrates a cross-sectional arrangement pitch having convex portions and concave portions, each of which is depicted as having a triangular cross-section. Pet. 24 (citing Ex. 1003, Fig. 2); *see* Ex. 1003 ¶ 14. As cones and pyramids necessarily have triangular cross-sections, we find that Nakashiba supports Petitioner's position that the reference discloses inherently "surface features" that include a member selected from the group recited in claim 8. *See* Pet. 24 (citing Ex. 1003, Fig. 2); *see* Ex. 1003 ¶ 14. Having considered the question of patentability anew based on our review of the complete record, we find that Nakashiba discloses the limitation recited in claim 8, as Petitioner establishes by a preponderance of the evidence. *See id.*

In view of the above, having considered the question of patentability anew based on our review of the complete record, we are persuaded that Petitioner establishes, by a preponderance of the evidence, that claims 1, 7, 8, and 13 are anticipated under 35 U.S.C. § 102 by Nakashiba. Petitioner, however, does not establish by a preponderance of the evidence that Nakashiba discloses, expressly or inherently, the limitations recited in claims 4 and 5, and therefore, that claims 4 and 5 are anticipated under 35 U.S.C. § 102 by Nakashiba.

E. Asserted Challenges Based on Mabuchi and Mazur

Petitioner contends claims 1, 2, 4, 5, 7–11, 13–18, 21, and 23–26 are unpatentable under 35 U.S.C. § 103 as obvious over the combination of Mabuchi

and Mazur. Pet. 39–50. Petitioner further contends claim 6 is unpatentable under 35 U.S.C. § 103 as obvious over the combination of Mabuchi, Mazur, and Uematsu and claim 12 is obvious over the combination of Mabuchi, Mazur, and Furukawa. *Id.* at 50–53. Patent Owner disputes Petitioner's contentions. PO Resp. 25–63. As noted above, the burden is on Petitioner to demonstrate unpatentability. *See Dynamic Drinkware*, 800 F.3d at 1378.

For the reasons that follow, Petitioner has demonstrated by a preponderance of the evidence that claims 1, 2, 4, 7–11, 13–18, 21, and 23–25 would have been obvious in light of Mabuchi and Mazur, and that claim 6 would have been obvious in light of Mabuchi, Mazur, and Uematsu. Petitioner has not demonstrated by a preponderance of the evidence that claims 5 and 26 would have been obvious in light of Mabuchi and Mazur, and that claim 12 would have been obvious in light Mabuchi, Mazur, and Furukawa.

1. Overview of Mabuchi

Mabuchi is entitled "Solid-State Image Pickup Device" and discloses a rear surface incidence type CMOS [Complementary Metal Oxide Semiconductor] image sensor having wiring layer 720 on a front surface of epitaxial substrate 710. Ex. 1006, [54], [57]. Figure 5, reproduced below, illustrates the CMOS image sensor and one pixel of image pickup pixel unit 700.

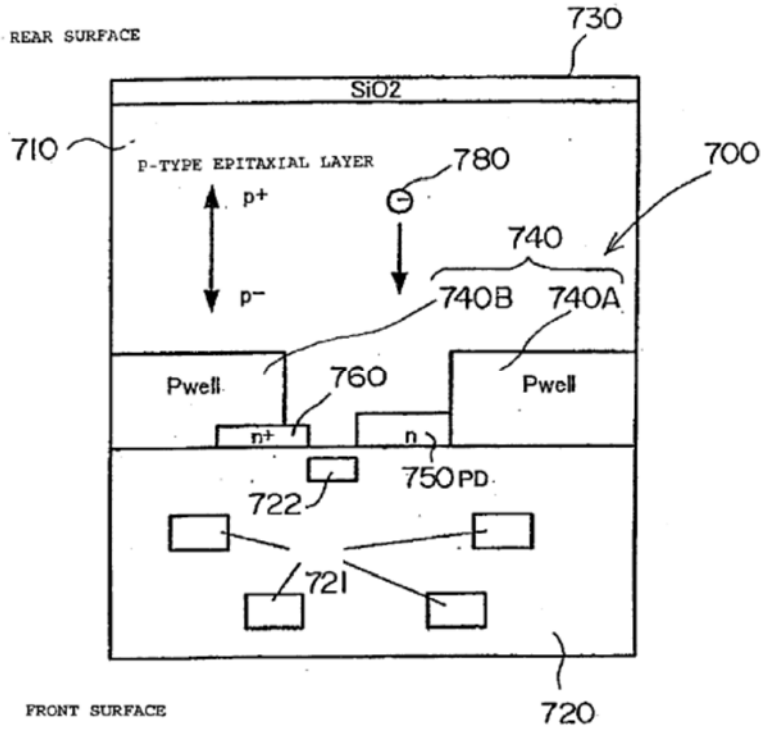


Figure 5 of Mabuchi illustrates a rear surface incidence type CMOS image sensor.

In Figure 5, wiring layer 720 includes "various wiring 721 formed by multilayer interconnection, a gate electrode 722 of a transfer transistor and the like" along "with an intermediate insulating layer." *Id.* ¶ 85. Silicon oxide film 730 is a light incident plane formed on a rear surface of epitaxial substrate 710. *Id.* ¶ 86. Mabuchi discloses "P-type well region 740 includes an n-type region 750 as a photoelectric converting region of the photodiode and an n+ type region 760 of an FD [floating diffusion] part" formed on the front surface side of epitaxial substrate 710. *Id.* ¶ 87.

2. Overview of Mazur

Mazur is entitled "Systems and Methods for Light Absorption and Field Emission Using Microstructured Silicon" and discloses microstructuring a silicon

sample to produce cone-like structures on a surface exposed to laser pulses. Ex. 1005, [54], [57]. Mazur discloses that "[s]uch microstructuring enhances the infrared absorbing, and current emission properties of the sample." *Id*. at [57]. Mazur further discloses that, "[i]n addition to using laser light to produce the cone-like structures, the semiconductor can also be exposed to a background gas to help form the structures." *Id*. ¶ 6. Mazur describes a microstructuring process of "irradiating the surface with a train of 800 nm, 100 fs laser pulse in the presence of a background gas such as SF_6" that "creates a quasi-ordered array of sharp conical microstructures up to fifty (50) micron high that are about 0.8 micron wide near the tip and up to ten (10) micron wide near the base." *Id*. ¶ 32. In Figure 3, reproduced below, a plot of absorptance versus wavelength is shown for a conventional crystalline silicon sample and three microstructured silicon samples.

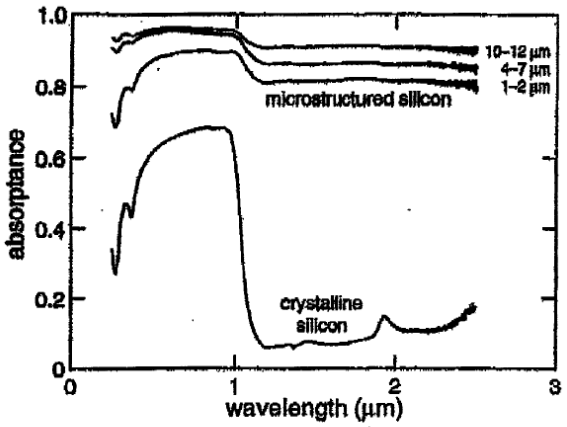


FIG. 3

Figure 3 of Mazur depicts a plot of absorptance versus wavelength for various silicon samples

According to Mazur, Figure 3 illustrates how "[e]ven for areas patterned with the smallest microstructures, only 1–2 micrometers tall, the optical absorptance over the wavelength 250 nm<λ<2.5 μm is substantially greater than that of flat, crystalline silicon." *Id*. ¶ 36. Mazur further discloses that "[f]or

wavelengths between 500 nm and 1.1 μm, the absorptance for these small microstructures is as high as 0.9" and that "[t]he absorptance drops at the band edge, as it does for flat silicon, but even for these longer wavelengths, λ>1.1 μm, the absorptance is greater than 0.8, or more than five times the absorptance of the flat, crystalline silicon." *Id.* Mazur also discloses that "[f]or the tallest microstructures studied, with heights of 10-12 μm, the absorptance is approximately 0.9 or greater across the entire wavelength region investigated." *Id*.

3. Overview of Uematsu

Uematsu is entitled "Light-Confining Structure and Light-Receiving Element Using the Same" and discloses "a light-confining structure which can reduce surface reflection and effectively confine light." Ex. 1009, [54], [57]. Uematsu discloses a substrate as well as a transition layer having depressions and projections that are repeated at an interval less equal to or less than the wavelength of light to be confined. *Id.* ¶ 6. In Figure 11, reproduced below, depressions and projections 11' are microscopic, have a triangular cross-section, and irregular size. *Id.* ¶ 24.

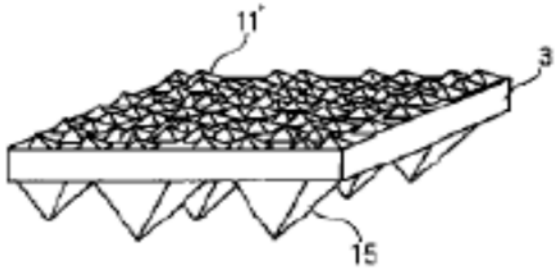


Figure 11 of Uematsu is a perspective view of the light-confining structure.

In Figure 11, microscopic depressions and projections 11' are shown on one side of substrate 3 and larger depressions and projections 15 are shown on the other side of substrate 3. *Id.* ¶ 23.

4. Overview of Furukawa

Furukawa is entitled "Solid-State Imaging Device" and discloses "a photoelectric conversion section which is provided for each pixel and which converts light incident on a first surface of a substrate into signal charges." Ex. 1007, [54], [57]. In Figure 2, reproduced below, Furukawa illustrates element isolation region 214 in semiconductor substrate 210.

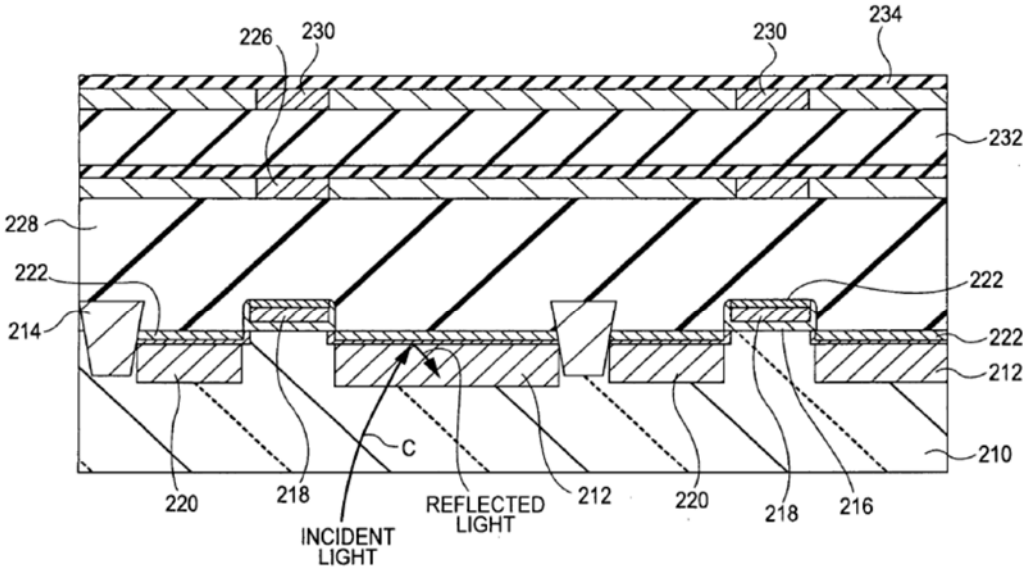


Figure 2 of Furukawa illustrates a cross-sectional view of the solid-state imaging device.

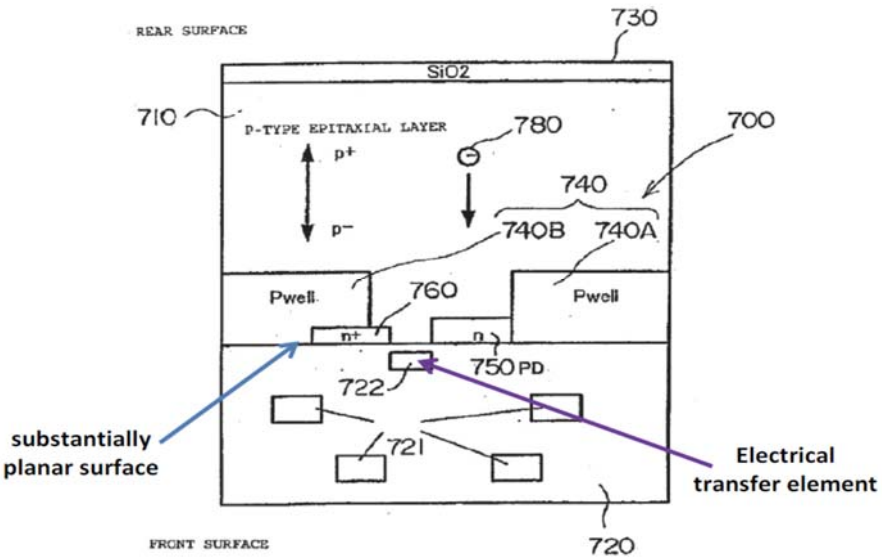
In Figure 2, "[a] light-receiving portion 212 of the photodiode receives light entering from the backside of the semiconductor substrate 210 and performs photoelectric conversion." *Id.* ¶ 34. Furukawa discloses that "[a] transfer transistor is disposed adjacent to the photodiode, and a gate electrode 218 is disposed on the substrate with a gate oxide film 216 therebetween." *Id.*

5. Analysis

a. Independent Claim 1

(1) "[a] photosensitive imager device, comprising: a semiconductor substrate having a substantially planar surface and multiple doped regions forming a least one junction"

According to Petitioner, "Mabuchi discloses a photosensitive imager device in the form of a rear surface incidence type (*i.e.*, back-illuminated) CMOS image sensor comprised of an epitaxial substrate 710 exhibiting p-type doping with an n-type region 750 forming at least one junction." Pet. 39. Petitioner further contends "[t]he epitaxial substrate 710 further includes a substantially planar surface on which a wiring layer 720 is formed." *Id.* (citing Ex. 1006, Fig. 5, ¶¶ 85–87; Ex. 1010 ¶¶ 204–206). Reproduced below is an annotated version of Mabuchi's Figure 5, with arrows added by Petitioner to designate a substantially planar surface and electrical transfer element.



Petitioner's annotated version of Figure 5 of Mabuchi depicts a photosensitive imager device.

Patent Owner does not provide specific arguments regarding Petitioner's contentions for this limitations. *See supra* at fn.6. Having considered the question of patentability anew based on our review of the complete record, we find that Mabuchi's epitaxial substrate 710 corresponds to the claimed "semiconductor substrate" and is demonstrated persuasively to include a substantially planar surface, as well as p-type doping 740 and n- type region 750 that form at least one junction. *See* Pet. 39 (citing Ex. 1006, Fig. 5, ¶¶ 85–87; Ex. 1010 ¶¶ 204–206). Thus, we find that Mabuchi teaches the "semiconductor substrate" and "multiple doped regions" as recited in claim 1. *See id.*

> *(2) "a textured region coupled to the semiconductor substrate on a surface opposite the substantially planar surface and positioned to interact with electromagnetic radiation"*

According to Petitioner, "Mabuchi does not teach that the epitaxial substrate 710 includes the claimed textured surface," but "Mazur teaches a method of microstructuring a silicon layer surface using femtosecond laser pulses in the presence of a background gas for enhancing light absorbing devices." Pet. 40 (citing Ex. 1010 ¶ 201). As rationale for combining the teachings of Mabuchi and Mazur, Petitioner contends

> Mazur provides an express teaching, motivation, or suggestion to combine the references, specifically because of its disclosure of increased optical absorptance in the wavelength range of 250 nm < λ <2.5 μm due to the microstructuring, which would therefore *improve the functionality of Mabuchi's CMOS image sensor over a large range of incident light wavelengths*. (*Id*. at ¶¶ 121-122, 202). Moreover, Mazur's texturing method is particularly convenient for the back side illumination architecture of Mabuchi's devices since the back side in the finished device is intended to be exposed to light.

Id. at 40–41 (emphasis added). Another basis set forth by Petitioner, however, is specific to improving sensitivity of a photodiode (i.e., corresponding to a pixel), as opposed to a CMOS image sensor that comprises more than one pixel. Reply 15 (citing Ex. 1005, Fig. 7; Ex. 1014 ¶ 61); *see* Pet. 40–41 (citing Ex. 1010 ¶ 202 (testifying as to rationale for combining Mabuchi and Mazur based on Mazur's express teaching of "applications of the texture therein to photodetectors" and knowledge of the ordinarily skilled artisan "that increasing the absorptance of the silicon substrates used in the devices of Mabuchi would be beneficial to the performance of said devices")); *see* Ex. 1010 ¶ 150 (citing Ex. 1005 ¶¶ 30, 44).

Patent Owner disputes Petitioner's position, contending that the ordinarily skilled artisan would not have had a reasonable expectation of success in combining the teachings of Mabuchi and Mazur to improve the functionality of Mabuchi's CMOS image sensor, in accordance with Petitioner's stated rationale, because the combination would result in unpredictable color mixing and a reduction in resolution in Mabuchi's CMOS image sensor and would "teach away" from Mabuchi's objective of reducing crosstalk in tightly packed pixels of the CMOS image sensor. PO Resp. 27 (citing *DePuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.*, 567 F.3d 1314, 1326 (Fed. Cir. 2009)), 37–54.

Initially, we clarify that Petitioner does not need to prove a reasonable expectation of success in achieving the objectives of either reference. *See Intelligent Bio-Systems, Inc. v. Illumina Cambridge Ltd.*, 821 F.3d 1359, 1368 (Fed. Cir. 2016) (holding that the failure of one reference to meet another reference's quantitative deblocking requirement was irrelevant to finding that there was no reasonable expectation of success in meeting the claims of the patent-in-suit, which did not require quantitative deblocking). Rather, it is necessary to show a reasonable expectation of success "in combining the references to meet the

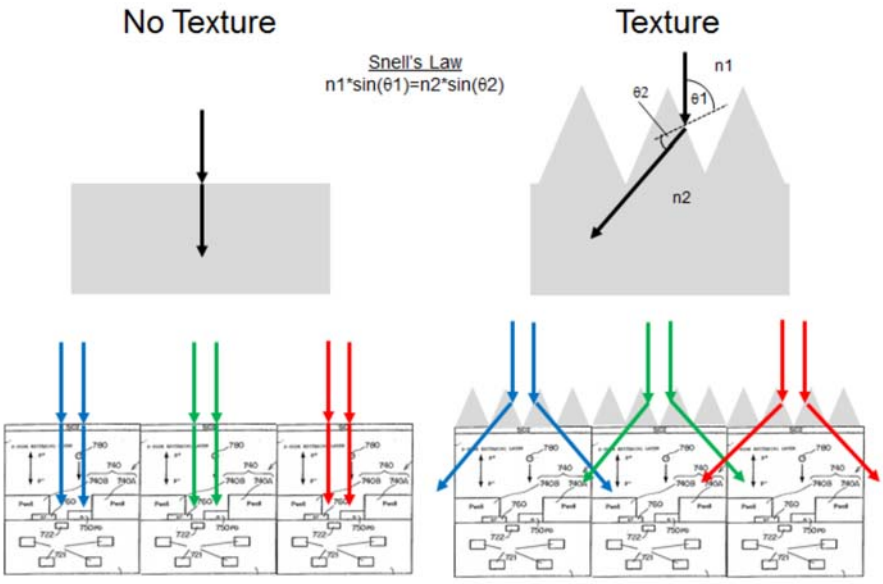
limitations of the claimed invention." *Id.* at 1367. Patent Owner's teaching away argument must be tied to the scope of the claimed invention, which may be broader than the disclosed objectives of either reference. *See Idemitsu Kosan Co., Ltd. v. SFC Co. Ltd.*, 870 F.3d 1376, 1381 (Fed. Cir. 2017) ("Evidence concerning whether the prior art teaches away from a given invention must relate to and be commensurate in scope with the ultimate claims at issue.") "A reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the applicant." *Ricoh Co., Ltd. v. Quanta Computer Inc.,* 550 F.3d 1325, 1332 (Fed. Cir. 2008) (quoting *In re Kahn,* 441 F.3d 977, 990 (Fed. Cir. 2006)). A reference does not teach away, however, if it merely expresses a general preference for an alternative invention but does not "criticize, discredit, or otherwise discourage" investigation into the invention claimed. *In re Fulton,* 391 F.3d 1195, 1201 (Fed. Cir. 2004).

For the reasons that follow, we find that the combined teachings of Mabuchi and Mazur are supported by a rationale for combining with sufficient rational underpinning and a reasonable expectation of success. We further find that the combined teachings of Mabuchi and Mazur would have produced predictable results. More particularly, we do not agree with Patent Owner's argument that the combined teachings of Mabuchi and Mazur teach away from the claimed invention, nor do we agree that modifying Mabuchi with the teachings of Mazur renders inoperable the teachings of Mabuchi. We now address each of Patent Owner's arguments in turn.

Optical Crosstalk Argument

Patent Owner takes the position that texturing Mabuchi's radiation-receiving surface would increase the likelihood of optical crosstalk and thus, color-mixing,

by scattering and/or redirecting photons to a neighboring pixel. PO Resp. 38–39 (arguing that texturing results in increased diffusion and scattering of at least a portion of the incident light); *see id.* at 52 (characterizing Mr. Guidash's testimony as supporting the position that "a degradation in the collection of charge carriers can more than offset any benefit provided by an increased generation of the carriers, and can thus result in degraded sensitivity."). Patent Owner refers to its own schematic, reproduced below, in support of these phenomena. *Id.* at 40.



Patent Owner's Schematic Diagram Illustrating Optical Crosstalk.

On the left of Patent Owner's schematic diagram above, light incident on an untextured surface is shown as entering the substrate absent redirection. *Id.* On the right of the schematic diagram, Patent Owner illustrates light incident on a textured surface being redirected via refraction. *Id.* Patent Owner asserts that redirected light can enter a neighboring pixel, for which the light was not intended. *Id.* Patent Owner argues that Dr. Souri did not consider whether the textured surface would increase scattering of incident light at the interface, as well as reduce reflection loss and increase path length. *Id.* at 34, 35.

Petitioner takes the position that not all light incident on a textured substrate will be redirected into a neighboring pixel, as depicted in Patent Owner's schematic diagram. *See* Reply 9–11. Petitioner replies "[w]hile PO is correct that applying a texture will increase scattering and diffusion of incident light, that does not necessarily equate to a substantial increase in optical crosstalk, which depends on a number of factors, including device layout, architecture, and elements designed to reduce optical crosstalk." *Id.* at 9 (citing Ex. 1014 ¶¶ 38, 39). Petitioner asserts that Mabuchi discloses a light shield layer, a color filter, and a microlens on the light incident surface, each of which serves to minimize optical crosstalk that leads to undesirable color-mixing. *See id.* at 11–12; *see* Ex. 1006 ¶ 86.

We concur with Petitioner's position. Mabuchi discloses (1) a "metal electrode 840 [that] can also be used as [a] light shield film for blocking light passing through an edge portion of the color filter formed for each pixel" (Ex. 1014 ¶ 53 (quoting Ex. 1006 ¶ 109)); (2) microlens 870 (Ex. 1006 ¶¶ 107, 109, Fig. 8), which Dr. Souri testifies "minimize[s] cross talk by condensing incident light toward the center of the photodiode through the aperture formed by the light shield," (Ex. 1014 ¶ 54); and (3) color filter 860 (Ex. 1006 ¶ 110, Fig. 8). We find that the contributions of Mabuchi's light shield layer, color filter, and microlens towards minimizing crosstalk are neither depicted in Patent Owner's schematic diagram nor accounted for in Mr. Guidash's testimony. *See* Reply 11–12. Mr. Guidash essentially acknowledges this point in his deposition testimony:

> [R]egardless of the function of those elements, the microlens, the color filter and the light shield, my opinion remains the same and the conclusion remains the same, that light that enters the textured surface of Mazur will undergo scattering and redirection and will cause optical and electrical crosstalk because of the size of the pixels of

> Mabuchi and the problem Mabuchi is trying to solve with higher resolution, smaller pixel devices.

Ex. 1015, 50:13–23.

We find that Patent Owner's schematic "unduly emphasize[s] the degree and severity of the effect, and misrepresent[s] the actual topography achieved by Mazur's texturing," and further, is not representative of Mazur's cones which have differing sizes and spacings. Reply 9–10 (citing Ex. 1014 ¶ 43; Ex. 1016, Figs. 2A–2D); *see* Ex. 2003 ¶ 82 (Patent Owner's own declarant, Mr. Guidash, testifying that the schematic is "greatly simplified" and noting that Mazur's textured region "would contain many irregular features across the array and within each pixel"). Patent Owner's schematic diagram also fails to account for the full range of feature sizes taught by Mazur (e.g., 1–12 μm) (Ex. 1005 ¶ 36) and silicon film layer thicknesses taught by Mabuchi (e.g., 5–50 μm) (Ex. 1006 ¶¶ 35, 38), as well as the "substantial improvement in absorption even for 'areas patterned with the smallest microstructures, only 1-2 micrometers tall'" and Mazur's teaching that the ordinarily skilled artisan would select features sizes appropriate for their application (Ex. 1005 ¶ 30). *See* Ex. 1014 ¶¶ 45, 46.

To the contrary, we credit the testimony of Dr. Souri, who testifies that Mazur's "topography would enhance diffusion of light into a substrate in multiple directions, not merely straight into adjacent pixels as Mr. Guidash's illustration suggests." Ex. 1014 ¶ 44. Dr. Souri's testimony is supported by the "trapping" concept described in the doctoral thesis of Claudia Wu (Ex. 1017, "Wu"), one of the inventors listed on the face of Mazur. Reply 10 (citing Ex. 1014 ¶ 44; Ex. 1017, 62). Wu discloses that texturing surfaces to enhance light absorption was a well-known method to reduce losses to reflection. Ex. 1017, 60. Wu further discloses that a large scale difference in the size of the textured surface as

compared with the wavelength of incident radiation causes "multiple reflections at the corrugated surface [which] cause the radiation to be trapped, [t]hereby enhancing the absorption." *Id.* at 60, 62. Wu also discloses that micron-scale texturing of silicon by generating random pyramidal structured surfaces reduces reflectance of visible and near-infrared light. *Id.* at 62, 63. Van Zegh Broeck (Ex. 1012) also discloses the trapping concept. *See* Pet. 5 (citing Ex. 1012, Figs. 5, 8, 5:27–67, 6:19–24).

Moreover, we note that optical cross-talk is a problem only when a device has more than one pixel, but none of the challenged claims require more than one pixel. Specifically, independent claims 1, 13, and 23 all recite only "at least one junction," which does not require more than one junction. As a result, Patent Owner's optical crosstalk argument is not commensurate with the scope of the claims. *Idemitsu Kosan Co., Ltd. v. SFC Co. Ltd.*, 870 F.3d 1376, 1381 (Fed. Cir. 2017) ("Evidence concerning whether the prior art teaches away from a given invention must relate to and be commensurate in scope with the ultimate claims at issue.").

Patent Owner also takes issue with what it characterizes as Petitioner's position that the difference in light absorption between a textured and untextured sample is solely due to absorption of photons by the textured layer of the textured sample, absent contribution from the underlying, untextured substrate. PO Resp. 41–43 (citing Ex. 2004, 63:2–20; Ex. 2003 ¶ 64). We do not understand this to be Petitioner's position. Moreover, we do not construe claim 1 of the '591 to require the "textured region" recited in claim 1 to provide an improved effect or difference in effect with respect to an untextured region. *Supra §* II.A.1. The scope of claim 1 broadly encompasses a textured region positioned to interact, which we construe to mean positioned to have any effect on electromagnetic radiation. *Id.*

Argument Regarding Irregularities

Patent Owner also argues that unpredictable and non-uniform color mixing, as well as reduced resolution, would result from applying Mazur's textured region, which contains irregular features, to Mabuchi's CMOS image sensor. PO Resp. 44 (citing Ex. 2003 ¶ 82) (Patent Owner's own declarant, Mr. Guidash, testifying that the schematic is "greatly simplified" and noting that Mazur's textured region "would contain many irregular features across the array and within each pixel"). Patent Owner cites Miyazaki (Ex. 2006), which is shown on its face as being assigned to Hamamatsu Photonics K.K., in support of its argument that increased absorption due to "irregular asperities" is accompanied by increased scattering. PO Resp. 45–46 (quoting Ex. 2006, 7:62–8:23); *see also id.* at 46 (quoting Ex. 2006, 8:37–39 ("Because of reflection, scattering, or diffusion by the asperity 10, the photodetector PS has a risk of a reduction in resolution due to the occurrence of crosstalk between pixels.")).

Miyazaki discloses how setting the semiconductor substrate thickness to be equal to or less than the pitch P of the pixels suppresses crosstalk. Ex. 2006, 8:40–43. Although Patent Owner quotes a portion of Miyazaki in column 8 in support of its assertion that "increased absorption . . . result[s] from the increased path length due to increased scattering by the textured surface," the same portion discloses that "the photodetector PS is improved in sensitivity characteristics in the near-infrared wavelength band." *Id.* at 8:20–22. Thus, Miyazaki does not support Patent Owner's argument regarding the unpredictability of combining the teachings of Mabuchi and Mazur.

Electrical Crosstalk Argument

Patent Owner also contends that the ordinarily skilled artisan would have realized that "crystalline damage to the near-surface region of silicon could

deactivate the P+-type acceptors in that region" and that "such deactivation could reduce or even reverse the electric field that *Mabuchi* relies on for preventing electrical cross-talk between pixels by guiding the electrons generated near the surface of the epitaxial layer via photoelectric conversion." PO Resp. 48–51 (citing Ex. 2003 ¶ 91; Ex. 2004, 110:20–24).

Petitioner takes the position that an increase in noise is accompanied by an increase in signal, which would result in an overall increase in signal-to-noise ratio. *See* Tr. 9:21–24 ("all of the negative side effects that Patent Owner advances in the Patent Owner response, are outweighed by the absorption that you're going to get from the texture and increase in signal"). Petitioner further asserts that Mabuchi teaches other dopant profiles that generate an electric field, each of which serves to guide charge to the appropriate photodetector and avoid electrical crosstalk. Reply 14-15 (citing Ex. 1014 ¶¶ 59, 60; Ex. 1006 ¶ 97); Ex. 1006 ¶ 97 (disclosing dopant profiles for generating an electric field, including p-type to i-type, or i-type to n-type). Petitioner also points to "a high resistance substrate and an electrode generated electric field, using the light shield layer as a field generator," for use in generating the electric field. *Id.* at 15 (citing Ex. 1014 ¶¶ 59–60; Ex. 1006 ¶¶ 106–108, Fig. 8).

We have reviewed the cited portions of Mabuchi in Figure 8 and paragraphs 97, 106, and 108 and we find that the cited evidence of record supports Dr. Souri's testimony and Petitioner's position that "one of ordinary skill in the art concerned about texturing affecting the p-type gradient could switch to alternate methods taught by Mabuchi for creating the electric field." Reply 15.

Argument Regarding Mabuchi's Objective

Patent Owner contends that the deleterious effects of color mixing and decreased resolution caused by a textured layer in the combined device of Mabuchi

and Mazur are more problematic for tightly packed pixels, to which Mabuchi is directed. PO Resp. 41 (citing Ex. 2003 ¶¶ 83–84); *see* Ex. 1015, 50:17–21 ("[L]ight that enters the textured surface of Mazur will undergo scattering and redirection and will cause optical and electrical crosstalk *because of the size of the pixels of Mabuchi*." (emphasis added)).

We note that Patent Owner's schematic diagram depicts *no* space between pixels and does not illustrate Mabuchi's color filter, light shield layer, or microlens and thus, Patent Owner's schematic diagram does not accurately or precisely depict the degree to which crosstalk affects Mabuchi's CMOS image sensor.

Moreover, Petitioner's challenge need not establish a reasonable expectation of success in meeting Mabuchi's objective of mitigating crosstalk in tightly packed pixels if that objective is not recited in the claims. *See Intelligent Bio-Systems,* 821 F.3d at 1368. Patent Owner's contention regarding Mabuchi's objective also is framed as an argument premised on Mazur's teaching away from Mabuchi. *See* PO Resp. 38–39. The relevant evidence, however, must also be tied to the scope of the claimed invention, which may be broader than the disclosed objectives of either reference. *See Idemitsu Kosan*, 870 F.3d at 1381; *see Owens Corning v. Fast Felt Corp.*, 873 F.3d 896, 902–903 (Fed. Cir. 2017).

As discussed above, none of the challenged claims require more than one pixel. Specifically, independent claims 1, 13, and 23 all recite only "at least one junction," which does not require more than one junction. As a result, Patent Owner's optical crosstalk argument is not commensurate with the scope of the claims. *Idemitsu Kosan*, 870 F.3d at 1381 ("Evidence concerning whether the prior art teaches away from a given invention must relate to and be commensurate in scope with the ultimate claims at issue."). For this reason, Patent Owner's contentions that Mabuchi's CMOS image sensor is not shown to have been

improved in functionality, as a whole, because texturing would cause increased scattering which would result in color mixing, and decreased resolution of the multi-pixel sensor as a whole, which is contrary to Mabuchi's objective are not commensurate in scope with the claims. *See* PO Resp. 38–39. Petitioner also does not have to address Mabuchi's objective in connection with its rationale for combining the teachings of Mabuchi and Mazur, for the reason discussed below.

Rationale for Combining and Reasonable Expectation of Success

One of Petitioner's rationales for combining the teachings of Mabuchi and Mazur is specific to improving the sensitivity and quantum efficiency of a photodiode in a pixel, as opposed to improving Mabuchi's CMOS image sensor, which corresponds to multiple pixels. Reply 15 (citing Ex. 1005, Fig. 7; Ex. 1014 ¶ 61); *see* Pet. 40–41 (citing Ex. 1010 ¶ 202 (testifying as to rationale for combining Mabuchi and Mazur based on Mazur's express teaching of "applications of the texture therein to photodetectors" and knowledge of the ordinarily skilled artisan "that increasing the absorptance of the silicon substrates used in the devices of Mabuchi would be beneficial to the performance of said devices")); *see* Ex. 1010 ¶ 150 (citing Ex. 1005 ¶¶ 30, 44).

Petitioner takes the position that texturing silicon was a well-known method of increasing absorptance of incident light, and even though the other deleterious effects argued by Patent Owner (e.g., crystalline damage, contamination of the P+ accumulation layer, increased dark current, image non-uniformity, reduced sensitivity, and fabrication difficulties) (*see* PO Resp. 48 (citing Ex. 2003 ¶ 89)) were known and understood, the ordinarily skilled artisan would have proceeded with texturing the silicon substrate as expressly motivated by Mazur and supported by the testimony of Petitioner's declarant and the underlying evidence in Moloney. *See* Reply 16–17; Ex. 1014 ¶¶ 64, 65; Ex. 1013, 8. We note that Petitioner's

challenge need not demonstrate a reasonable expectation of success in eliminating or addressing the deleterious effects argued by Patent Owner because such effects are not a requirement of the claim. Additionally, these deleterious effects do not form the basis of Petitioner's rationale and thus, need not be addressed in connection therewith insofar as the evidence discussed below *expressly* teaches increased absorptance associated with texturing a photodiode.

Petitioner argues that, not only does Mazur directly contradict Patent Owner's proposition regarding crystalline damage, as discussed above, "Mazur demonstrates improved absorption *and signal response* is possible even without passivating the material." Reply 15–16 (citing Ex. 1005 ¶ 46, Fig. 7; Ex. 1014 ¶¶ 61, 62); *see id.* at 17–18. We have reviewed the cited portions of Mazur in Figure 7 and paragraphs 36 and 46 and agree with Petitioner that Mazur demonstrates that a "texture applied to an avalanche photodiode increased the sensitivity of the device by generating a higher *signal* as compared to an untextured device" and that "the textured device had 'more than threefold increase in quantum efficiency of radiation at 1.31 μm,' with 'similar results' for 1.06 μm light." *Id.* at 15 (citing Ex. 1005 ¶ 46, Fig. 7); *see* Ex. 1005 ¶ 36.

The cited evidence underlying Dr. Souri's testimony, Moloney, discloses that texturing silicon reduces reflection, "enlarges the surface area of the diode[,] and increases the effective diode thickness as the light repeatedly bounces back and forth between the spikes." Ex. 1013, 1. In the experiment described in Moloney, black silicon photodiodes were generated by etching spikes of silicon that "have the effect of absorbing all the incoming light, turning the surface black," when they reach a certain height. *Id.* at 2. Although Moloney discloses that "[t]he breakdown voltages and dark currents of the black silicon diodes tended to be slightly higher than those for the standard diodes," Moloney also notes that the

phenomena "*was due to the position of the black silicon diodes on the wafer*, as characteristics tended to vary across the wafer, *rather than due to the black silicon coating*." *Id.* at 6 (emphases added). Moloney also discloses that a "greater than 50 % increase in responsivity, at long wavelengths, was observed for back illumination" of black silicon diodes. *Id.* at 8. Accordingly, Moloney supports Petitioner's position and Dr. Souri's testimony.

Webb also supports Petitioner's position. Webb discloses contouring a light entry surface with "a regular array of indentations extending a distance into the photodiode thereby reducing the reflectivity of the entry surface or increasing the light absorption length in the photodiode." Ex. 1011, 2:22–28; *see* Pet. 4 (citing Ex. 1011, 1:29–32). Webb further discloses that these indentations are micron-sized. *See* Pet. 4 (citing Ex. 1011, 2:43–45, 3:46–63, Fig. 1). Webb discloses that the surface contouring (i.e., the regular array of indentations) results in a 41% quantum efficiency for an avalanche photodiode, as compared with a 20% quantum efficiency for an uncontoured photodiode. Ex. 1011, 7:21–26. Similarly, Van Zegh Broeck discloses roughened surface 23 of detector membrane 18 (i.e., substrate) that traps light by causing random scattering such that most of the light will make several passes through detector membrane 18 and results in absorption of most of the light. Ex. 1012, 5:32–34, 6:22–25.

Thus, Petitioner's rationale for applying texture, as taught by Mazur, to Mabuchi's photodiode in a pixel discussed above is supported by sufficient rational underpinning because there is an express motivation in Mazur (Ex. 1005 ¶¶ 36, 46, Fig. 7), and it is supported by Dr. Souri's testimony and underlying evidence that shows that the ordinarily skilled artisan would have textured a light-receiving surface of a photodiode having been aware of the well-known absorptance benefits resulting from texturing (Ex. 1011, 2:22–28, 7:21–26; Ex. 1012, 5:32–34, 6:22–

25), and further, would have done so, having recognized the difficulties associated with the same (Ex. 1013, 6, 8).

Because each of Mazur, Moloney, Webb, and Van Zegh Broeck discloses that texturing a photodiode would result in increased absorptance, we find that the cited evidence of record supports a finding of predictability, and thus, a reasonable expectation of success in applying texture, as taught by Mazur, to Mabuchi's photodiode. For these same reasons, the complete record before us does not support a finding that texturing Mabuchi's photodiode in accordance with the teachings of Mazur would teach away from claim 1 or render Mabuchi's photodiode inoperable to absorb light. *See* PO Resp. 27–28, 38–39. Furthermore, because the record contains express disclosures in Mazur, Moloney, Webb, and Van Zegh Broeck of texturing light-receiving surfaces of photodiodes and recognizing the resultant benefit of increased absorptance, we disagree with Patent Owner that Petitioner's challenge relies on impermissible hindsight. *See id.* at 54.

Impermissible Hindsight

Patent Owner also contends that Petitioner's position relies on impermissible hindsight. PO Resp. 54. This contention is not persuasive because Petitioner's challenge is supported by the references themselves and the knowledge of one of ordinary skill in the art as evidenced by the prior art, instead of being derived from the challenged claims, as discussed above. *See Insite Vision Inc. v. Sandoz, Inc.*, 783 F.3d 853, 859 (Fed. Cir. 2015) ("Defining the problem in terms of its solution reveals improper hindsight in the selection of the prior art relevant to obviousness.").

Having considered the question of patentability anew based on our review of the complete record, we determine that Petitioner has provided a reason for combining teachings of Mabuchi and Mazur that is supported by sufficient rational

underpinning and a reasonable expectation of success in achieving the combination and we find that the combination of Mabuchi and Mazur teaches the "textured region" as recited in claim 1. *See KSR*, 550 U.S. at 418.

(3) "integrated circuitry formed at the substantially planar surface"

According to Petitioner, "[i]ntegrated circuitry, in the form of four transistors 220, 230, 240, 250 per photodiode, are provided at this planar surface, as shown by Figs. 2, 3, and 5." Pet. 39 (citing Ex. 1006, Figs. 2, 3, 5, ¶¶ 68, 69; Ex. 1010 ¶¶ 210–213). Patent Owner does not provide specific arguments regarding Petitioner's contentions for this limitation. *See supra* at fn.6.

Having considered the question of patentability anew based on our review of the complete record, we find that Mabuchi's transistors 220, 230, 240, 250 are illustrated in Figs. 2, 3, and 5 as being formed at the planar surface of Mabuchi's epitaxial substrate 710. *See* Pet. 39 (citing Ex. 1006, Figs. 2, 3, 5, ¶¶ 68, 69; Ex. 1010 ¶¶ 210–213). Accordingly, we find that Mabuchi teaches the "integrated circuitry" as recited in claim 1. *See id.*

(4) "an electrical transfer element coupled to the semiconductor substrate and operable to transfer an electrical signal from the at least one junction"

According to Petitioner, "gate electrode 722 of the transfer transistor 220 is coupled to the epitaxial substrate 710 *via* the wiring layer 720 and functions to transfer the signal from the p-n junction to an adjacent diffusion region 760." *Id.* (citing Ex. 1006, Fig. 5, ¶ 87; Ex. 1010 ¶ 215). Patent Owner does not provide specific arguments regarding Petitioner's contentions for these limitations. *See* PO Resp. 3–13; *see supra* at fn.6.

Mabuchi discloses that "[t]he gate electrode 722 of the transfer transistor operates to output signal charge accumulated in the n-type region 750 of the

photodiode to the n+ type region 760 of the FD part." Ex. 1006 ¶ 87. Mabuchi illustrates, and Dr. Souri testifies, that gate electrode 722 is within wiring layer 720, which is adjacent to epitaxial substrate 710. *Id.* at Fig. 5; Ex. 1010 ¶ 215. We credit the testimony of Dr. Souri, who testifies that the ordinarily skilled artisan would understand the teachings of Mabuchi to "apply[] a voltage to transfer electrode 722 such that the resulting electric field induces a conducting channel in semiconductor substrate 700, and thus would consider said electrode to be coupled to said substrate." Ex. 1010 ¶ 215.

Having considered the question of patentability anew based on our review of the complete record, we find that Mabuchi teaches the "electrical transfer element" as recited in claim 1. Pet. 39 (citing Ex. 1006, Fig. 5, ¶ 87; Ex. 1010 ¶ 215).

In view of the above, we conclude that the combination of Mabuchi and Mazur renders obvious the subject matter recited in claim 1, as Petitioner establishes by a preponderance of the evidence.

b. Independent Claims 13 and 23

Claims 13 and 23 recite features substantially similar to those recited in claim 1. We find that Petitioner's arguments presented with respect to claim 1 also are persuasive with respect to claims 13 and 23 for substantially similar reasons. *See* Pet. 46, 49–50; Ex. 1010 ¶¶ 229–34, 243–47. Patent Owner does not argue the limitations of claims 13 and 23 separately from claim 1. Accordingly, our analysis with respect to claim 1 is applicable to claims 13 and 23. *See supra* § II.E.5.a.

Furthermore, with respect to claim 23, Petitioner contends Mabuchi teaches four MOS transistors: transfer transistor 220, reset transistor 230, amplifying transistor 240, and selecting (address) transistor 250. Pet. 49 (citing Ex. 1006 ¶ 68). Petitioner quotes Mabuchi's teaching that gate electrode 722 of transfer transistor 220 "operates to output a signal charge accumulated in the n-type region

750 of the photodiode." *Id.* (quoting Ex. 1006 ¶ 87). Petitioner also contends Figures 2, 3, and 5 "show[] that the four MOS transistors are formed at the planar surface of the epitaxial substrate 710." *Id.* at 49–50 (citing Ex. 1010 ¶¶ 246, 247). We find that Mabuchi discloses four transistors formed in wiring layer 720, which is adjacent to the substantially planar surface of epitaxial substrate 710, and gate electrode 722 that operates to transfer electrical charge from Mabuchi's n-type region 750. *Id.* at 49–50 (citing Ex. 1006 ¶¶ 68, 87; Ex. 1010 ¶¶ 246, 247). Accordingly, we find that Mabuchi teaches "at least 4 transistors formed at the substantially planar surface at least one of the transistors electrically coupled to the at least one junction," as recited in claim 23. *See id.*

Having considered the question of patentability anew based on our review of the complete record, we conclude that the combination of Mabuchi and Mazur renders obvious the subject matter recited in claims 13 and 23, as Petitioner establishes by a preponderance of the evidence. *See* Pet. 46, 49–50; Ex. 1010 ¶¶ 229–34, 243–47.

c. Dependent Claims 2, 7–11, 14–18, 21, 24, and 25

Claim 2 recites, *inter alia,* "wherein the transfer element is selected from the group consisting of a transistor, a sensing node, a transfer gate, and combinations thereof." Claim 21 recites, *inter alia*, "wherein the transfer element is selected from the group consisting of a transistor, a sensing node, a transfer gate, and combinations thereof." Petitioner contends that Mabuchi teaches that the claimed "transfer element" is "a transfer gate." Pet. 43, 48 (citing Ex. 1006 ¶ 87, Fig. 5; Ex. 1010 ¶¶ 215–19, 242). We find the cited portion of Mabuchi discloses that "[t]he gate electrode 722 of the transfer transistor operates to output signal charge accumulated in the n-type region 750 of the photodiode to the n+ type region 760 of the FD part." Ex. 1006 ¶ 87. Accordingly, we find that Mabuchi teaches that its

transfer element is a transfer gate. *See id.* Patent Owner does not provide specific arguments regarding these dependent claims. *See supra* at fn.6. Having considered the question of patentability anew based on our review of the complete record, we conclude that the combination of Mabuchi and Mazur renders obvious the subject matter recited in claims 2 and 21, as Petitioner establishes by a preponderance of the evidence. *See* Pet. 43, 48 (citing Ex. 1010 ¶¶ 218, 219, 242).

Claim 4 recites, *inter alia*, "wherein the textured region has a surface morphology operable to direct electromagnetic radiation into or out of the semiconductor substrate." Petitioner cites paragraph 36 of Mazur in support of this teaching. Pet. 32 (citing Ex. 1005 ¶ 36; Ex. 1010 ¶¶ 149–151); *see id.* at 43 (citing Ex. 1010 ¶ 220). We find that Mazur discloses, "[a]s the heights of the structures increase, so does the optical absorptance both below and above the band gap." Ex. 1005 ¶ 36. Dr. Souri testifies that "[a]lthough Mazur does not define the exact mechanism by which the increase in absorption is achieved, one of ordinary skill in the art would understand that the effect is in part due to increased transmission of the incident light through the textured surface . . . because, at the time of the '591 patent, it was well known that the reflectivity of a surface could be reduced, resulting in a corresponding increase in the transmission through said surface, via the use of surface texture." Ex. 1010 ¶ 149. Patent Owner does not provide specific arguments regarding this dependent claim. *See supra* at fn.6. We find that Mazur teaches preventing reflection by increasing transmission through a semiconductor substrate and thus, that the combination of Mabuchi and Mazur at least suggests that the "surface morphology [is] operable to direct electromagnetic radiation into . . . the semiconductor substrate," as recited in claim 4. *See* Ex. 1005 ¶ 36; *see* Ex. 1010 ¶ 149. Having considered the question of patentability anew based on our review of the complete record, we conclude that the combination of

Mabuchi and Mazur renders obvious the subject matter recited in claim 4, as Petitioner establishes by a preponderance of the evidence. Pet. 32 (citing Ex. 1005 ¶ 36; Ex. 1010 ¶¶ 149–151); *see id.* at 43 (citing Ex. 1010 ¶ 220).

Claim 5 recites, *inter alia*, "the surface morphology of the textured region relative to the semiconductor substrate is a member selected from the group consisting of sloping, pyramidal, inverted pyramidal, spherical, parabolic, asymmetric, symmetric, and combinations thereof." Claim 5 depends from claim 4. Petitioner cites paragraph 30 of Mazur in support of this teaching. Pet. 32 (citing Ex. 1005 ¶ 30; Ex. 1010 ¶¶ 152, 153); *see id.* at 43–44 (citing Ex. 1010 ¶ 221). We find Mazur discloses that "[m]icrostructured samples, such as those composed of primarily silicon having a plurality of cone-like structures formed thereon by laser light, have many applications, which include their use in light absorbing devices, such as solar cells, photodetectors, and other photovoltaic devices." Ex. 1005 ¶ 30. Accordingly, we find that Mazur teaches "the surface morphology of the textured region relative to the semiconductor substrate is . . . sloping," as recited in claim 4. *See id.* Patent Owner does not provide specific arguments regarding this dependent claim. *See supra* at fn.6. Having considered the question of patentability anew based on our review of the complete record, we conclude that the combination of Mabuchi and Mazur renders obvious the subject matter recited in claim 5, as Petitioner establishes by a preponderance of the evidence. *See* Pet. 32 (citing Ex. 1005 ¶ 30; Ex. 1010 ¶¶ 152, 153); *see id.* at 43–44 (citing Ex. 1010 ¶ 221).

Claim 7 recites, *inter alia*, "wherein the textured region includes surface features having a size selected from the group consisting of micron-sized, nano-sized, and combinations thereof." Claim 15 recites, *inter alia*, "wherein forming the textured region includes irradiating a target region with laser radiation to form

surface features having a size selected from the group consisting of micron-sized, nano-sized, and combinations thereof." Petitioner contends that the claimed "surface features" are micron-sized. Pet. 33 (citing Ex. 1005 ¶ 32; Ex. 1010 ¶¶ 154, 155, 158, 159); *see id.* at 44, 47 (citing Ex. 1010 ¶¶ 222, 236). We find Mazur discloses a microstructuring process that "creates a quasi-ordered array of sharp conical microstructures up to fifty (50) micron high that are about 0.8 micron wide near the tip and up to ten (10) micron wide near the base." Ex. 1005 ¶ 32. Accordingly, we find Mazur teaches micron-sized surface features. *See id.* Patent Owner does not provide specific arguments regarding these dependent claims. *See supra* at fn.6. Having considered the question of patentability anew based on our review of the complete record, we conclude that the combination of Mabuchi and Mazur renders obvious the subject matter recited in claims 7 and 15, as Petitioner establishes by a preponderance of the evidence. *See* Pet. 33 (citing Ex. 1005 ¶ 32; Ex. 1010 ¶¶ 154, 155, 158, 159); *see id.* at 44, 47 (citing Ex. 1010 ¶¶ 222, 236).

Claim 8 recites, *inter alia*, "wherein surface features include a member selected from the group consisting of cones, pillars, pyramids, micolenses, quantum dots, inverted features, and combinations thereof." Petitioner contends that the claimed "surface features" are cones. Pet. 33 (citing Ex. 1005 ¶ 32; Ex. 1010 ¶¶ 156, 157); *see. id.* at 44 (citing Ex. 1010 ¶ 223). We find that Mazur discloses that the microstructuring process "creates a quasi-ordered array of sharp *conical* microstructures." Ex. 1005 ¶ 32 (emphasis added). Accordingly, we find Mazur teaches surface features including conical members. *See id.* Patent Owner does not provide specific arguments regarding this dependent claim. *See supra* at fn.6. Having considered the question of patentability anew based on our review of the complete record, we conclude that the combination of Mabuchi and Mazur renders obvious the subject matter recited in claim 8, as Petitioner establishes by a

preponderance of the evidence. *See* Pet. 33 (citing Ex. 1005 ¶ 32; Ex. 1010 ¶¶ 156, 157); *see. id.* at 44 (citing Ex. 1010 ¶ 223).

Claim 9 recites, *inter alia,* "wherein the textured region has been formed by a process selected from the group consisting of lasing, chemical etching, and combinations thereof." Claim 14 recites, *inter alia*, "wherein forming the textured region is by a process selected from the group consisting of lasing, chemical etching, nanoimprinting, material deposition, and combinations thereof." Claim 17 recites, *inter alia*, "wherein the irradiation is performed using a pulsed laser including a member selected from the group consisting of a femtosecond laser, a picosecond laser, a nanosecond laser, and combinations thereof." Claim 24 recites, *inter alia*, "wherein the textured region has been formed by lasing." Claim 25 recites, *inter alia*, "wherein the textured region has been formed by lasing with short duration laser pulses." Petitioner contends that Mazur teaches that the claimed "textured region" is formed by a lasing process. Pet. 33, 35, 38 (citing Ex. 1005 ¶ 32; Ex. 1010 ¶¶ 158, 159, 169, 170, 195–197); *see id.* at 44, 46, 50 (citing Ex. 1010 ¶¶ 224, 235, 248, 249). Petitioner further contends that Mazur discloses that the irradiation is performed using a pulsed, femtosecond laser. *Id.* at 36 (citing Ex. 1010 ¶¶ 179, 180); *see id.* at 47 (citing Ex. 1010 ¶ 238). We find Mazur teaches that "[t]he sample 12 can include, for example, a silicon sample having a surface that can be microstructured by irradiating the surface with a train of 800 nm, *100 fs laser pulses* in the presence of a background gas such as SF_6." Ex. 1005 ¶ 32 (emphasis added). Dr. Souri testifies that femtosecond pulses would have been understood to be short by one of ordinary skill in the art. Ex. 1010 ¶ 249; *see id.* ¶ 196 ("A femtosecond is equal to $1x10^{-15}$ of a second, and is among the shortest duration of pulses that can be created by lasers."). Patent Owner does not provide specific arguments regarding these dependent claims. *See supra* at fn.6.

Having considered the question of patentability anew based on our review of the complete record, we conclude that the combination of Mabuchi and Mazur renders obvious the subject matter recited in claim 9, 14, 17, 24, and 25, as Petitioner establishes by a preponderance of the evidence. *See* Pet. 33, 35, 36, 38 (citing Ex. 1005 ¶ 32; Ex. 1010 ¶¶ 158, 159, 169, 170, 179, 180, 195–197); *see id.* at 44, 46, 47, 50 (citing Ex. 1010 ¶¶ 224, 235, 238, 248, 249).

Claim 10 recites, *inter alia*, "a lens optically coupled to the semiconductor substrate and positioned to focus incident electromagnetic radiation into the semiconductor substrate." Petitioner contends that Mabuchi teaches the claimed "lens." Pet. 45 (quoting Ex. 1006 ¶ 86; citing Ex. 1010 ¶¶ 225, 226). We find Mabuchi teaches that "[a] silicon oxide film (SiO2) 730 is formed on the rear surface of the epitaxial substrate 710 to form a light incidence plane," and that "a light shield film, a color filter, a microlens and the like are provided in a layer over the silicon oxide film 730." Ex. 1006 ¶ 86. As discussed above, Mabuchi discloses microlens 870 (Ex. 1006 ¶¶ 107, 109, Fig. 8), which Dr. Souri testifies "minimize[s] cross talk by condensing incident light toward the center of the photodiode through the aperture formed by the light shield." Ex. 1014 ¶ 54. Patent Owner does not provide specific arguments regarding this dependent claim. *See supra* at fn.6. Having considered the question of patentability anew based on our review of the complete record, we conclude that the combination of Mabuchi and Mazur renders obvious the limitation recited in claim 10, as Petitioner establishes by a preponderance of the evidence. *See* Pet. 45 (quoting Ex. 1006 ¶ 86; citing Ex. 1010 ¶¶ 225, 226).

Claim 11 recites "[a] photosensitive imager array, comprising at least two photosensitive imager devices of claim 1." Petitioner contends Mabuchi depicts multiple photodiodes 200 arrayed adjacently and discloses "a solid-state image

pickup device . . . comprising: a semiconductor substrate having an image pickup pixel unit formed by arranging a plurality of pixels each including a photoelectric converting device and a reading circuit therefor in a two-dimensional array." Pet. 45–46 (citing Ex. 1006 ¶ 43, Fig. 3; Ex. 1010 ¶¶ 227, 228). We have reviewed the cited portions of Mabuchi and find that Mabuchi teaches a plurality of photosensitive imager devices of claim 1 arranged in an array. *See id.* Patent Owner does not provide specific arguments regarding this dependent claim. *See supra* at fn.6. Having considered the question of patentability anew based on our review of the complete record, we conclude that the combination of Mabuchi and Mazur renders obvious the subject matter recited in claim 11, as Petitioner establishes by a preponderance of the evidence. *See* Pet. 45–46 (citing Ex. 1006 ¶ 43, Fig. 3; Ex. 1010 ¶¶ 227, 228).

Claim 16 recites, *inter alia*, "wherein irradiating the target region includes exposing the laser radiation to a dopant such that the irradiation incorporates the dopant into the textured region." Petitioner cites paragraphs 6 and 77 of Mazur as teaching this limitation. Pet. 35–36 (citing Ex. 1005 ¶¶ 6, 77; Ex. 1010 ¶¶ 173–78); *see id.* at 47 (citing Ex. 1010 ¶ 237). We find Mazur discloses that, "[i]n addition to using laser light to produce the cone-like structures, the semiconductor can also be exposed to a background gas to help form the structure." Ex. 1005 ¶ 6. We further find Mazur teaches that "[t]he background gas can include a halogenic gas, i.e., a gas containing a halogen, such as SF_6," and that "the predetermined background gas is determined to introduce states in the silicon substrate that absorb infrared energy and produce photocurrent in response thereto." *Id.* ¶ 77; *see also* Ex. 1001, 12:53–56 ("[An] S dopant material includes not only S, but also any material capable [of] being used to dope S into the target region, such as, for example, H_2S, SF_6, SO_2, and the like."). Patent Owner does not provide specific

arguments regarding this dependent claim. *See supra* at fn.6. Having considered the question of patentability anew based on our review of the complete record, we conclude that the combination of Mabuchi and Mazur renders obvious the subject matter recited in claim 16, as Petitioner establishes by a preponderance of the evidence. *See* Pet. 35–36 (citing Ex. 1005 ¶¶ 6, 77; Ex. 1010 ¶¶ 173–78); *see id.* at 47 (citing Ex. 1010 ¶ 237).

Claim 18 recites, *inter alia,* "further comprising tuning an electrical response of the photosensitive imager device." Petitioner cites Figures 3 and 4 of Mazur as teaching the limitation recited in claim 18. Pet. 36 (citing Ex. 1005, Figs. 3, 4; Ex. 1010 ¶¶ 181–84); *see id.* at 47 (Ex. 1010 ¶ 239). Petitioner contends that "[t]he absorption by the textured surface can be varied by altering, for example, the dimensions of the microstructures (Fig. 3), which also correspond to the thickness of the textured region." *Id.* at 36. We find that Figure 3 of Mazur illustrates absorptance curves that are dependent on microstructure spike heights, with 10–12 μm spikes showing the best absorptance a particular wavelength range. Ex. 1005, Fig. 3. We further find Mazur teaches that selecting a particular size of microstructure spike height tunes an increased absorptance response over particular wavelengths. *See id.* Patent Owner does not provide specific arguments regarding this dependent claim. *See supra* at fn.6. Having considered the question of patentability anew based on our review of the complete record, we conclude that the combination of Mabuchi and Mazur renders obvious the limitation recited in claim 18, as Petitioner establishes by a preponderance of the evidence. *See* Pet. 36 (citing Ex. 1005, Figs. 3, 4; Ex. 1010 ¶¶ 181–84); *see id.* at 47 (Ex. 1010 ¶ 239).

d. Dependent Claim 26

Claim 26 recites, *inter alia*, "wherein the semiconductor substrate includes monocrystal silicon." Petitioner does not cite to Mabuchi or Mazur as teaching

monocrystalline silicon. *See* Pet. 50; *compare id.*, *with id.* at 38–39 (citing Ex. 1004, 4:45–51). Accordingly, we find Petitioner fails to establish that the combination of Mabuchi and Mazur teaches or suggests the limitation recited in claim 26. *See* Pet. 50.

e. Dependent Claim 6

Claim 6 recites, *inter alia*, "an additional textured region positioned on a surface of the semiconductor substrate that is adjacent the multiple doped regions." According to Petitioner, Mazur does not teach texturing multiple surfaces, but Uematsu teaches "a light-receiving element based on a p-type silicon substrate 21 having microscopic depressions and [projections] 11' formed on a light incident surface while V-shaped grooves exhibiting a repeating width of 2 μm are formed on the opposite surface" upon which "[a] high density n-type layer 20 is formed." Pet. 50–51 (citing Ex. 1009 ¶ 24, Fig. 12; Ex. 1010 ¶ 256). Petitioner contends it would have been obvious to one of ordinary skill in the art to combine the teachings of Mabuchi and Uematsu because "[b]oth references are in the same field of endeavor, *i.e.*, improving photodetector devices to enhance detection" and "to further improve the device sensitivity, particularly in the infrared wavelengths." *Id.* at 51 (citing Ex. 1006 ¶ 38; Ex. 1009 ¶ 24; Ex. 1010 ¶¶ 251–252).

Patent Owner contends that, "contrary to *Mabuchi's* efforts to reduce irregular reflections from its wiring layer (*see* Ex. 1006 at [0025], [0119]), Petitioner's proposed modification could instead increase the coupling of light to the wiring layer (720), thereby increasing irregular reflections therefrom and the possibility of optical cross-talk." PO Resp. 56–57 (citing Ex. 2003 ¶ 99). Petitioner argues that "rather than coupling light to the wiring layer, the V-grooves of Uematsu are intended to *confine light within the substrate* before it ever enters

the wiring layer, thereby reducing the amount of light that is incident on the metal wires within the wiring layer." Reply 21 (citing Ex. 1014 ¶¶ 73, 75).

We have reviewed Petitioner's contentions and the supporting evidence. Pet. 50–51; Ex. 1006 ¶ 38; Ex. 1009 ¶ 24, Fig. 12; Ex. 1010 ¶¶ 251–257. We find that, in addition to microscopic depressions and projections 11', Uematsu teaches V-shaped grooves that are formed at the same surface as high density n-type layer 20. *See, e.g.,* Ex. 1009 ¶ 24, Fig. 12. We further find that Figure 12 and paragraph 22 of Uematsu (Ex. 1009) support Petitioner's position that "[o]ne of ordinary skill in the art would[,] therefore[,] expect Uematsu's V-grooves to *reduce* optical crosstalk." Reply 21 (citing Ex. 1014 ¶ 75); *see* Ex. 1009 ¶ 22 ("V-grooves 13 having a repeating width of 2 μm were formed on the rear surface of the silicon substrate 3 . . . [and] the light incident from the front surface was reflected by the rear surface, totally reflected when it reached the front surface again, and was confined inside the silicon substrate.").

We determine that Petitioner articulates a reason for modifying the Mabuchi-Mazur combination with the teachings of Uematsu that is supported by sufficient rational underpinning and we conclude that that the combination of Mabuchi, Mazur, and Uematsu renders obvious the subject matter recited in claim 6, as Petitioner establishes by a preponderance of the evidence. *See* Pet. 50–51 (citing Ex. 1006 ¶ 38; Ex. 1009 ¶ 24, Fig. 12; Ex. 1010 ¶¶ 251–257); *see* Ex. 1009 ¶ 22; *see* Ex. 1014 ¶ 75; *see KSR*, 550 U.S. at 418.

f. Dependent Claim 12

Claim 12 recites, *inter alia*, "at least one trench isolation positioned between the at least two photosensitive imager device[s]." According to Petitioner, "while Mabuchi teaches a plurality of pixels, each having a photodiode and accompanying four transistors, there is no express description regarding how the pixels are

separated from one another." Pet. 52 (citing Ex. 1010 ¶ 259). Petitioner contends "one of ordinary skill in the art would recognize that pixels in Mabuchi must be isolated from one another, and so at least sufficient space must be left between pixels to achieve this function." *Id.* (citing Ex. 1010 ¶ 260). Petitioner cites Furukawa as teaching "a backside-illuminated CMOS image sensor very similar to that of Mabuchi, including doped photodiode regions, floating diffusion regions, and four transistors per pixel" in which individual pixels are isolated from one another "using isolation regions 214 in the form of filled trenches extending into the substrate 210." *Id.* (citing Ex. 1007 ¶¶ 31–34, Fig. 2; Ex. 1010 ¶¶ 258, 264).

As rationale for modifying the Mabuchi-Mazur combination with Furukawa, Petitioner contends that the modification is "nothing more than the combining of known elements according to known methods to yield the predictable result of isolating individual pixels" and that "[o]ne of ordinary skill in the art would have recognized that such trenches may offer superior isolation of adjacent pixels when compared to simply spacing the pixels apart, thereby enabling smaller pixel densities and improved resolution." *Id.* at 52–53 (citing Ex. 1010 ¶¶ 261, 264, 265).

Patent Owner contends

> [A] person skilled in the art would appreciate that *Furukawa*'s isolation region (214) could be formed without the generation of a trench, for example, via local oxidation of the semiconductor substrate (210) (a LOCOS isolation region), Petitioner has failed to demonstrate that *Furukawa* discloses a "trench isolation" as recited in claim 12.

PO Resp. 62.

Petitioner replies that "it is certainly reasonable to infer that the isolation regions 214 in Furukawa can be formed by trenches, and one of ordinary skill in the

art would have been predisposed to assuming the same." Reply 22 (citing Ex. 1010 ¶¶ 258–65; Ex. 1014 ¶ 84). We agree with Petitioner that it is not necessary for Petitioner to show that Furukawa's isolation regions could *not* have been formed by trenches. *Id.* Although we construed the term "trench isolation" to require removal of a material via, for example, etching, we declined to limit this claim term to that which is formed for the purpose of reducing optical or electrical crosstalk. *Supra* § II.A.2. Therefore, we disagree that "trench isolation" as recited in claim 12 does not encompass Furukawa's isolation regions.

Patent Owner further contends that

> [A] person of ordinary skill in the art would not have been motivated to incorporate *Furukawa*'s isolation elements (214) into *Mabuchi*'s image sensor because *Mabuchi* is itself designed to electrically isolate adjacent pixels using an internal electric field generated by the dopant gradient in each pixel's epitaxial layer. *See* Ex. 2003 at ¶¶57-58, 84.

Id. at 62.

Petitioner replies that "[t]he internal electric field of Mabuchi addresses electrical isolation, while Furukawa's isolation region *could* additionally address optical isolation, thereby providing another benefit." *Id.* at 25 (Ex. 1014 ¶ 94) (emphasis added). In connection with Petitioner's stated rationale for combining the teachings of Furukawa with Mabuchi and Mazur set forth above, we consider the issue of whether the complete record supports the finding that the ordinarily skilled artisan would have understood Furukawa's isolation regions to address or reduce optical crosstalk, as Petitioner contends. *See id.*

In his first declaration, Dr. Souri testified that "Mabuchi does not explicitly teach how the multiple pixel devices should be kept separate from each other." Ex. 1010 ¶ 259. He further testifies that "Furukawa explicitly teaches that isolation

trenches may be used to separate pixels, and so one of ordinary skill in the art would understand that such trenches may offer superior isolation of adjacent pixels than leaving a space." *Id.* ¶ 261. Thus, we do not understand Petitioner's initial position to be based on addressing *optical* crosstalk in particular. *Id.*

In his second declaration, Dr. Souri testifies that "Mabuchi's electric field addresses electrical isolation, whereas the isolation regions of Furukawa address optical isolation and therefore provide an additional benefit." Ex. 1014 ¶ 94. He further testifies that "even though Mabuchi addresses isolation via an electric field technique, this does not mean that the incorporation of other additional techniques would not lead to increased isolation." *Id.* Even assuming that Petitioner's reliance on Furukawa for addressing optical crosstalk had formed the basis of its initial position, Dr. Souri's testimony does not address Mabuchi's light shield layer, color filter, and microlens, which Petitioner asserts are elements designed to minimize optical crosstalk. Reply 11–12. More particularly, Dr. Souri's testimony does not cite the underlying testimony that supports Petitioner's assertion that incorporating Furukawa's isolation regions in Mabuchi's device would lead to increased isolation (Ex. 1010 ¶ 261), or any additional benefit (*see* Ex. 1014 ¶ 94) beyond that which is provided by Mabuchi's light shield layer, color filter, and microlens. *See* 37 C.F.R. § 42.65(a) ("Expert testimony that does not disclose the underlying facts or data on which the opinion is based is entitled to little or no weight.")

For the foregoing reasons, we find that the complete record fails to support, by a preponderance of the evidence, Petitioner's rationale for modifying the Mabuchi-Mazur combination with the teachings of Furukawa. *See KSR*, 550 U.S. at 418.

F. Petitioner's Motion to Exclude

Petitioner timely filed Objections to Patent Owner's Response Evidence (Paper 30), followed by a Motion to Exclude (Paper 37), to which Patent Owner filed an Opposition (Paper 40). Petitioner moves to exclude Choi (Ex. 2010) and portions of the Second Declaration of Mr. Guidash (Ex. 2003) on the grounds that Choi was published in 2013, and therefore, is not prior art or even contemporaneous with the '591 patent. *See* Paper 37. Even without considering Choi and the objected portions of the Second Declaration of Mr. Guidash, we determine that Petitioner's arguments and evidence do not meet the preponderance of the evidence standard for establishing obviousness of claim 12 over Mabuchi, Mazur, and Furukawa. As a result, we dismiss Petitioner's Motion to Exclude as moot.

III. CONCLUSION

For the foregoing reasons, we conclude that Petitioner has demonstrated by a preponderance of the evidence the unpatentability of claims 1, 2, 4–11, 13–18, 21, and 23–25 of the '591 patent, but has not demonstrated by a preponderance of the evidence that claims 12 and 26 are unpatentable. Specifically, Petitioner has demonstrated by a preponderance of the evidence that (1) claims 1, 7, 8, and 13 are anticipated under 35 U.S.C. § 102 by Nakashiba; (2) claims 1, 2, 4, 5, 7–11, 13–18, 21, and 23–25 would have been obvious in light of Mabuchi and Mazur; and (3) claim 6 would have been obvious in light of Mabuchi, Mazur, and Uematsu. Petitioner has not demonstrated by a preponderance of the evidence that (1) claims 4 and 5 are anticipated under 35 U.S.C. § 102 by Nakashiba; (2) claim 26 would

have been obvious in light of Mabuchi and Mazur; and (3) claim 12 would have been obvious in light Mabuchi, Mazur, and Furukawa.

IV. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that claims 1, 2, 4–11, 13–18, 21, and 23–25 of the '591 patent have been shown by a preponderance of the evidence to be *unpatentable*;

FURTHER ORDERED that claims 12 and 26 are not held unpatentable;

FURTHER ORDERED that Petitioner's Motion to Exclude Evidence is *dismissed* as moot; and

FURTHER ORDERED that, because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

HAMAMATSU CORPORATION
Petitioner,

v.

SIONYX, LLC
Patent Owner.

Case IPR2016-01910
Patent 8,680,591 B2

Before GEORGIANNA W. BRADEN, MATTHEW R. CLEMENTS, and MONICA S. ULLAGADDI, *Administrative Patent Judges*.

CLEMENTS, *Administrative Patent Judge*, concurring.

I agree with the majority's determination that claims 4 and 5 are unpatentable under 35 U.S.C. § 103 as obvious over the combination of Mabuchi and Mazur, but I respectfully disagree with the majority's determination that Petitioner did not establish, by a preponderance of the evidence, that claims 4 and 5 are unpatentable under 35 U.S.C. § 102 as anticipated by Nakashiba.

Claim 4 recites "wherein the textured region has a surface morphology operable to direct electromagnetic radiation into or out of the semiconductor

substrate." Claim 5 depends from claim 4 and recites "wherein the surface morphology of the textured region relative to the semiconductor substrate is a member selected from the group consisting of sloping, pyramidal, inverted pyramidal, spherical, parabolic, asymmetric, symmetric, and combinations thereof." With respect to claim 4, the majority determines that:

> Petitioner's challenge does not persuade us, by a preponderance of the evidence, that it is the *surface morphology* that necessarily directs at least some of the incident light into the semiconductor substrate. Petitioner's challenge leaves open the possibility that: (1) it is only the differences in indices of refraction that affects the path of incident light; as well as the possibility that (2) the path of incident light is not affected or changed at all, for example, when it is perpendicularly incident on roughened contact surface S1 and thus, is not "*directed into* . . . the semiconductor substrate." In view of the above, the arguments and evidence presented by Petitioner do not support, by a preponderance of the evidence, the finding that Nakashiba discloses, expressly or inherently, "the textured region has a surface morphology operable to direct electromagnetic radiation into . . . the semiconductor substrate," as recited in claim 4, contrary to Petitioner's contention.

Majority Opinion ("Maj. Op.") 27–28. With respect to claim 5, the majority determines that "[a]t least because Petitioner fails to establish that Nakashiba discloses the limitation recited in claim 4, Petitioner also fails to establish that Nakashiba discloses the limitation recited in claim 5." *Id.* at 28.

Claim 4 requires only that the textured region have a surface morphology "operable to direct electromagnetic radiation into ***or*** out of the semiconductor substrate." Ex. 1001, 18:53–55 (emphasis added). Thus, the claim encompasses a surface "operable to" absorb light ("direct . . . into"), reflect light ("direct . . . out of"), or some combination thereof. The claim is so broadly written that I cannot think of a surface that would not satisfy the limitation—i.e., that would neither absorb nor reflect light. Nakashiba teaches roughened surface S1, which is

depicted in Figure 2 as a pyramidal surface as claimed in dependent claim 5. Pet. 22–23; Ex. 1010 ¶¶ 104–106. Petitioner relies upon Nakashiba's disclosure that light passes through surface S1. *Id.* Patent Owner did not provide specific arguments regarding Petitioner's contentions for these limitations.

Because claim 4 is so broad and because Nakashiba teaches the narrower limitation of claim 5, which depends from claim 4, I am persuaded that Petitioner has established, by a preponderance of the evidence, that Nakashiba discloses the limitations of both claim 4 and claim 5.