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Paper 84
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PUBLIC VERSION

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SEMICONDUCTOR COMPONENTS INDUSTRIES, LLC and
TEXAS INSTRUMENTS INCORPORATED
Petitioner,

v.

GREENTHREAD LLC,
Patent Owner.

IPR2023-01244[1]
Patent 11,121,222 B2

Before GRACE KARAFFA OBERMANN, JON B. TORNQUIST, and MONICA S. ULLAGADDI, *Administrative Patent Judges*.

ULLAGADDI, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining All Challenged Claims Unpatentable
35 U.S.C. § 318(a)

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[1] Texas Instruments Incorporated, which filed a petition in IPR2024-00674, has been joined as a petitioner in this proceeding. Paper 68.

I. INTRODUCTION

A. Background and Summary

Semiconductor Components Industries, LLC ("Petitioner") filed a petition for an *inter partes* review (Paper 2 ("Pet.")) challenging claim 44 of U.S. Patent No. 11,121,222 B2 (Ex. 1001, "the '222 patent"). In addition, Petitioner filed a paper explaining and ranking the parallel petitions challenging the '222 patent, i.e., the present Petition and the petition filed in IPR2023-01242. Paper 3. Greenthread, LLC ("Patent Owner" or "PO") filed a Preliminary Response (Paper 18, "Prelim. Resp."). With our authorization, Petitioner filed a Preliminary Reply (Paper 22), and Patent Owner filed a Preliminary Sur-Reply (Paper 28).

Upon review of the preliminary record, we instituted *inter partes* review, pursuant to 35 U.S.C. § 314, as to the challenged claim based on the challenges set forth in the Petition. Paper 35 ("Institution Decision" or "Inst. Dec."). Patent Owner filed a Response (Paper 46, "Patent Owner's Response" or "PO Resp."), Petitioner filed a Reply to Patent Owner's Response (Paper 61, "Petitioner's Reply" or "Pet. Reply"), and Patent Owner filed a Sur-Reply (Paper 64, "Patent Owner's Sur-Reply" or "PO Sur-Reply").[2] On November 13, 2024, we held an oral hearing. A transcript of the hearing is of record. Paper 82 ("Tr.").

For the reasons that follow, we conclude that Petitioner has established, by a preponderance of the evidence, that challenged claim 44 of the '222 patent is unpatentable.

[2] Except where noted, we cite to redacted versions of Patent Owner's Preliminary Response (Paper 55), Patent Owner's Response (Paper 58), Patent Owner's Sur-Reply (Paper 65), and Petitioner's Reply (Paper 70).

B. Real Parties-in-Interest

Each party identifies itself as a real party-in-interest. Pet. 1; Paper 5, 2. In addition, Petitioner identifies ON Semiconductor Corporation as a real party-in-interest. Pet. 1. Texas Instruments Incorporated was joined as a petitioner in this proceeding, and identifies itself as a real party-in-interest. Paper 68, 3.

C. Related Matters

The parties identify several proceedings involving the '222 patent as related matters, including *Greenthread, LLC v. ON Semiconductor Corp.*, No. 1:23-cv-00443 (D. Del.); *Greenthread, LLC v. Western Digital Corp.*, No. 1:23-cv-00326 (D. Del.); *Greenthread, LLC v. Cirrus Logic, Inc.*, 1:23-cv-00369 (W.D. Tex.); *Greenthread, LLC v. Texas Instruments Inc.*, No. 2:23-cv-00157 (E.D. Tex.); *Greenthread, LLC v. OSRAM GmbH*, No. 2:23-cv-00179 (E.D. Tex.); *Greenthread, LLC v. OmniVision Technologies, Inc.*, No. 2:23-cv-00212 (E.D. Tex.); *Greenthread, LLC v. Monolithic Power Systems, Inc.*, No. 1:23-cv-00579 (D. Del.); *Greenthread, LLC v. Intel Corp.*, No. 6:22-cv-105 (W.D. Tex.); *Greenthread, LLC v. Intel Corp.*, No. 6:22-cv-01293 (W.D. Tex.); *Greenthread, LLC v. Micron Technology, Inc.*, No. 1:23-cv-00333 (D. Del.); *Intel Corp. v. Greenthread, LLC*, IPR2023-00420 (PTAB); *Intel Corp. v. Greenthread, LLC*, IPR2023-00552 (PTAB); *Dell Technologies Inc. v. Greenthread, LLC*, IPR2023-00509 (PTAB); and *Sony Group Corp. v. Greenthread, LLC*, IPR2023-00324 (PTAB). Pet. 1–3; Paper 5, 2–5.

In addition, Petitioner challenges claims 1–9, 13–28, and 32–42 of the '222 patent in IPR2023-01242, currently pending. Paper 3, 3. Further, Patent Owner identifies two additional matters involving the '222 patent: *Cirrus*

Logic, Inc. v. Greenthread, LLC, IPR2024-00020 (PTAB); and *Cirrus Logic, Inc. v. Greenthread, LLC*, IPR2024-00021 (PTAB). Paper 16, 2.

D. The '222 Patent

The '222 patent, titled "Semiconductor Devices with Graded Dopant Regions," issued on September 14, 2021. Ex. 1001, codes (45), (54). The '222 patent "relates to all semiconductor devices and systems." *Id.* at 1:23–24. According to the '222 patent, in bipolar junction transistors, "[e]fforts have been made in graded base transistors to create an aiding drift field to enhance the diffusing minority carrier's speed from emitter to collector" versus the standard "uniformly doped base." *Id.* at 1:34–48. This improvement has not been implemented in "most semiconductor devices, including various power MOSFETs [and] IGBT's," which "still use a uniformly doped 'drift epitaxial' region in the base." *Id.* at 1:48–53.

The invention of the '222 patent implements graded dopant concentration in these devices, which causes "[t]wo important performance enhancements." *Id.* at 3:4–31. These include sweeping electrons "from source to drain rapidly" and simultaneously causing holes to "be recombined closer to the n^+ buffer layer," which "can improve t_{on} and t_{off} in the same device." *Id.* at 3:31–35.

E. Illustrative Claim 44

Petitioner challenges claim 44, which is reproduced below (with bracketing numbering added by Petitioner).

> 44. [**pre**] A CMOS Semiconductor device comprising:
>
> [**44.1**] a surface layer;
>
> [**44.2**] a substrate;
>
> [**44.3**] an active region including a source and a drain, disposed on one surface of the surface layer;

> [**44.4**] a single drift layer disposed between the other surface of the surface layer and the substrate, the drift layer having a graded concentration of dopants extending between the surface layer and the substrate, [**44.5**] the drift layer further having a first static unidirectional electric drift field to aid the movement of carriers from the surface layer to an area of the substrate where there are no active regions; and
>
> [**44.6**] at least one well region disposed in the single drift layer, the well region having a graded concentration of dopants and a second static unidirectional electric drift field to aid the movement of carriers from the surface layer to the area of the substrate where there are no active regions.

Ex. 1001, 8:21–39; *see generally* Pet. (bracketed numbering).

F. Asserted Unpatentability Challenges

Petitioner asserts that claim 44 is unpatentable based on the following challenges:

Claim Challenged	35 U.S.C. §	Reference(s)/Basis
44	103(a)[3]	Payne[4]
44	103(a)	Sakai,[5] Kawagoe [6]

Petitioner relies on the Declaration of Travis Blalock, Ph.D. Ex. 1003. Patent Owner relies on the Declaration of Alexander Glew, Ph.D. Ex. 2057.

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[3] The Leahy-Smith America Invents Act, Pub. L. No. 112–29, 125 Stat. 284 (2011) ("AIA"), included revisions to 35 U.S.C. § 103 that became effective after the effective filing date of the challenged claims. *See* Ex. 1001, codes (22), (60). Therefore, we apply the pre-AIA versions of 35 U.S.C. § 103.

[4] U.S. Patent No. 4,684,971 to Payne, issued Aug. 4, 1987 (Ex. 1005, "Payne").

[5] U.S. Patent No. 4,907,058 to Sakai, issued Mar. 6, 1990 (Ex. 1006, "Sakai").

[6] U.S. Patent No. 6,043,114 to Kawagoe et al., filed Sept. 22, 1997 and issued Mar. 28, 2000 (Ex. 1007, "Kawagoe").

II. ANALYSIS

A. Legal Standards

"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). The burden of persuasion never shifts to Patent Owner. *Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015).

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." 35 U.S.C. § 103(a). 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 ordinary skill in the art; and (4) when present, objective evidence of nonobviousness. *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

To show obviousness, it is not enough to merely show that the prior art includes separate references covering each separate limitation in a challenged claim. *Unigene Labs., Inc. v. Apotex, Inc.*, 655 F.3d 1352, 1360 (Fed. Cir. 2011). "Rather, obviousness requires the additional showing that a person of ordinary skill at the time of the invention would have selected and combined those prior art elements in the normal course of research and development to yield the claimed invention." *Id.* (citing *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 421 (2007)). "This is so because inventions in

most, if not all, instances rely upon building blocks long since uncovered, and claimed discoveries almost of necessity will be combinations of what, in some sense, is already known." *KSR*, 550 U.S. at 418–19. On the other hand, an obviousness analysis "need not seek out precise teachings directed to the specific subject matter of the challenged claim, for a court can take account of the inferences and creative steps that a person of ordinary skill in the art would employ." *Id.* at 418; *accord In re Translogic Tech., Inc.*, 504 F.3d 1249, 1259 (Fed. Cir. 2007). Nevertheless, "[a] factfinder should be aware, of course, of the distortion caused by hindsight bias and must be cautious of arguments reliant upon *ex post* reasoning." *KSR*, 550 U.S. at 421.

B. Level of Ordinary Skill in the Art

In determining the level of ordinary skill in the art, various factors may be considered, including the "type of problems encountered in the art; prior art solutions to those problems; rapidity with which innovations are made; sophistication of the technology; and educational level of active workers in the field." *In re GPAC Inc.*, 57 F.3d 1573, 1579 (Fed. Cir. 1995).

Petitioner asserts that a person of ordinary skill in the art "would have had a Bachelor's degree in electrical engineering, material science, applied physics, or a related field, and four years of experience in semiconductor design and manufacturing or equivalent work experience." Pet. 5–6 (citing Ex. 1003 ¶ 48). According to Petitioner, "[a]dditional education might compensate for less experience, and vice-versa." *Id.*

Patent Owner argues that

> [a] person of ordinary skill in the art (POSITA) in the technology field of the Challenged Patent would be a person with at least a Bachelor's of Science degree in electrical or computer engineering, materials science, chemical engineering, applied

> physics, or a related field, with emphasis on semiconductor manufacturing, or an equivalent degree, and at least four years of experience in semiconductor design and manufacturing. Additional education in a relevant field or industry experience may compensate for a deficit in one of the other aspects of the requirements stated above.

PO Resp. 11 (citing Ex. 2057 ¶¶ 17–18).

Petitioner's and Patent Owner's definitions for the level of ordinary skill in the art are substantially similar. In light of the record before us, we adopt Petitioner's proposal regarding the level of ordinary skill in the art. Based on our review of the '222 patent and the prior art of record, we determine that the definition offered by Petitioner comports with the qualifications a person would have needed to understand and implement the teachings of the '222 patent and the prior art. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001) (explaining that specific findings regarding ordinary skill level are not required "where the prior art itself reflects an appropriate level and a need for testimony is not shown") (quoting *Litton Indus. Prods., Inc. v. Solid State Sys. Corp.*, 755 F.2d 158, 163 (Fed. Cir. 1985)). Patent Owner does not argue that the outcome of our Decision depends on which party's definition is selected, nor does it.

C. Claim Construction

In an *inter partes* review, we construe claim terms according to the standard set forth in *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–17 (Fed. Cir. 2005) (en banc). 37 C.F.R. § 42.100(b) (2023). Under *Phillips*, claim terms are afforded "their ordinary and customary meaning." *Phillips*, 415 F.3d at 1312. "[T]he ordinary and customary meaning of a claim term is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention." *Id.* at 1313. "Importantly, the person

of ordinary skill in the art is deemed to read the claim term not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the specification." *Id.*

Neither party proposes any claim terms for *express* construction. Pet. 6; PO Resp. 11–12 (citing Ex. 2057 ¶¶ 20–25, 45). However, Patent Owner implicitly construes "at least one graded dopant concentration to aid carrier movement" to require carrier movement, and Petitioner disagrees. We address the implicit construction below.

After considering the arguments and information presented during trial, we agree that we do not need to expressly construe any terms in order to decide the disputed issues. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (citing *Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999) ("[O]nly those terms need be construed that are in controversy, and only to the extent necessary to resolve the controversy.")).

D. Challenge Based on Payne

Petitioner contends claim 44 would have been obvious in view of Payne. Pet. 5, 11–40.

1. Overview of Payne

Payne "relates to complementary field effect transistors formed by ion implantation, and in particular to a structure and method of fabrication which permit high packing density." Ex. 1005, 1:5–8. According to Payne, CMOS devices "comprise n-channel and p-channel devices formed in the same substrate," and they were traditionally "formed by diffusion or implantation of a p-type 'tub' in an n-type silicon substrate so that the n-channel device is fabricated in the tub and the p-channel device is fabricated

in the adjacent portion of the substrate." *Id.* at 1:9–18. This method "led to the constraint that the concentration at the surface in the tub was much greater than the surface concentration of the substrate." *Id.* at 1:18–21.

To avoid this constraint, Payne states that one method was "to form the p-channel device in a second tub of n-conductivity type and higher impurity concentration than a more lightly doped substrate." *Id.* at 1:24–27. "Using either the single tub or twin tub approach, a considerable amount of semi-conductor area is needed due to the fact that the tub impurities will diffuse laterally as well as vertically during the drive-in to establish the desired tub depth." *Id.* at 1:34–38. Payne states that "[t]his is particularly troublesome in the twin-tub process since any significant overlap of the two tubs results in decreased doping concentration of each tub at the boundaries which can cause punch through or field inversion channeling during device operation." *Id.* at 1:39–43. This problem required large spacing of the source and drain regions of the transistors, and Payne seeks to avoid this need by "provid[ing] a CMOS structure and method of manufacture which requires little semiconductor space." *Id.* at 1:43–54.

In particular, Payne's "device is fabricated in a silicon semiconductor substrate, 10, of 'N--' conductivity type which . . . is typically approximately 20 mils thick." Ex. 1005, 2:56–60. On this substrate, tub regions 15 and 17 are formed, one "having the same conductivity type as the substrate but higher impurity concentration" and the other having the opposite conductivity type. *Id.* at 3:35–39, 4:12–14, Figs. 2–5. Surface regions 18 and 20 are formed "covering essentially the same area as" tubs 15 and 17, with each region having the same conductivity type as the tub over which it lies but with higher impurity concentration. *Id.* at 4:31–5:17, Figs. 7–9, 11.

Payne's CMOS device includes a "p-channel device [that] includes source and drain regions, 21 and 22, respectively, of P+ conductivity type formed with[in] the N surface region, 18" and an "n-channel device [that] includes source and drain regions, 23 and 24, of N+ conductivity type formed within the P surface region 20." *Id.* at 5:21–27, Fig. 10. Payne states that this approach can reduce the spacing between "source and drain regions of adjacent devices" from 12 microns to 5 microns. *Id.* at 5:54–6:19, Figs. 12, 13.

2. Petitioner's Contentions

Petitioner argues that Payne would have taught or suggested the limitations of claim 44. Pet. 8–40.

[pre] *"[a] CMOS Semiconductor device"*

Petitioner argues that Payne teaches the preamble. Pet. 12. Payne discloses that "a primary object of [its] invention [is] to provide a CMOS structure and method of manufacture which requires little semiconductor space." Ex. 1005, 1:51–54.

Patent Owner does not contest Petitioner's evidence pertaining to the preamble of claim 44. We determine that Petitioner demonstrates by a preponderance of evidence that Payne teaches the subject matter of the preamble of claim 44. As such, we need not and do not determine whether the preamble of claim 44 is limiting.

[44.1] *"a surface layer"*

Petitioner argues that Payne teaches or suggests this limitation. Pet. 12–14. Petitioner cites evidences that shows that Payne discloses a surface layer similar to that in the '222 patent. Ex. 1001, Fig. 5(b); Ex. 1003 ¶¶ 68–70; Ex. 1005, 2:50–60, 5:21–27, 6:57–59, Fig. 10; Ex. 1030, 6, 7, 9, 12, 13;

Ex. 1033. In particular, Figure 5(b) of the '222 patent and Payne's Figure 10 show quite similar structures, and Patent Owner's district court claim construction brief identified the relevant structure in Figure 5(b) of the '222 patent as a surface layer. Ex. 1030, 7, 12.

Patent Owner does not contest Petitioner's evidence pertaining to this limitation of claim 44. We determine that Petitioner demonstrates by a preponderance of evidence that Payne teaches this limitation of claim 44.

*[**44.2**] "a substrate"*

Petitioner argues that Payne teaches this limitation. Pet. 14–15. Payne discloses fabricating its CMOS device "in a silicon semiconductor substrate." Ex. 1005, 1:60–65, 2:50–60, Fig. 10.

Patent Owner does not contest Petitioner's evidence pertaining to this limitation of claim 44. We determine that Petitioner demonstrates by a preponderance of evidence that Payne teaches this limitation of claim 44.

*[**44.3**] "an active region including a source and a drain, disposed on one surface of the surface layer"*

Petitioner argues that Payne teaches this limitation. Pet. 15–18. Payne discloses forming p-channel and n-channel transistors, each with source and drain regions. Ex. 1005, 1:5–19, 5:18–29, 6:57–59. Petitioner cites evidence that a person of ordinary skill in the art would have considered the transistors to be active regions. Ex. 1001, Fig. 5(b); Ex. 1030, 6–7, 11; Ex. 1003 ¶¶ 75–77; Ex. 1008B, 299–300.

Patent Owner does not contest Petitioner's evidence pertaining to this limitation of claim 44. We determine that Petitioner demonstrates by a preponderance of evidence that Payne teaches this limitation of claim 44.

> ***[44.4]*** *"a single drift layer disposed between the other surface of the surface layer and the substrate, the drift layer having a graded concentration of dopants extending between the surface layer and the substrate"*

Petitioner argues that Payne teaches this limitation. Pet. 18–24. Payne discloses a first tub region with a surface region in it that, on the present record, appears quite similar to the single drift layer and well region of the '222 patent. *Compare* Ex. 1003 ¶ 82; Ex. 1005, 3:28–43, 4:19–39, 5:7–17, 5:44–50, *with* Ex. 1001, Fig. 5(b); Ex. 1030, 7, 11. Payne's Figure 11 shows a dopant concentration in tubs 15, 17 that decreases with increasing depth. Ex. 1005, 2:38–41, 5:14–17, 5:56–57, Figs. 10, 11.

Patent Owner does not contest Petitioner's evidence pertaining to this limitation of claim 44. We determine that Petitioner demonstrates by a preponderance of evidence that Payne teaches this limitation of claim 44.

> ***[44.5]*** *"the drift layer further having a first static unidirectional electric drift field to aid the movement of carriers from the surface layer to an area of the substrate where there are no active regions"*

Petitioner argues that Payne teaches this limitation. Pet. 24–33. Petitioner points to the file history of parent U.S. Patent No. 8,421,195 ("the '195 patent") and cited references and argues that the presence of a graded dopant concentration similar to that in Payne "creates a 'built-in' electrical field that forces the movement of carriers into a particular direction" and that the direction in which carriers are forced with the concentration profile disclosed in Payne is downward, toward the substrate and away from the surface. Pet. 26–31 (citing Ex. 1010, 2:27–32, 5:14–22; Ex. 1020, 289–90) (emphasis omitted). Payne discloses that its active regions are located on the

surface, rather than in the substrate. Ex. 1005, 1:5–15, 1:51–54, 2:50–60, 3:28–4:25, 4:31–5:12, 5:18–29, Figs. 1–10.

Patent Owner disputes Petitioner's evidence pertaining to limitation [44.5]. We resolve the dispute about this limitation in our analysis below.

> ***[44.6]*** *"at least one well region disposed in the single drift layer, the well region having a graded concentration of dopants and a second static unidirectional electric drift field to aid the movement of carriers from the surface layer to the area of the substrate where there are no active regions"*

Petitioner argues that Payne teaches this limitation. Pet. 33–40. Petitioner argues that Payne's tub region 15 satisfies this claim limitation to the same extent as the well region that Patent Owner identifies in Figure 5(b) of the '222 patent, and that this layer has a graded concentration of dopants. Pet. 34–36 (citing Ex. 1001, Fig. 5(b); Ex. 1030, 7; Ex. 1005, 1:65–68, 4:31–39, 4:63–5:14, 5:44–55, Figs. 10–11). Petitioner contends that the presence of this layer creates a second "static unidirectional electric drift field that aids the movement of minority carriers from the surface layer to the area of the substrate where there are no active regions." Pet. 38–39; Ex. 1003 ¶¶ 117–121.

Patent Owner disputes Petitioner's evidence pertaining to limitation [44.6]. We resolve the dispute about this limitation in our analysis below.

3. Patent Owner's Arguments

Patent Owner disputes Petitioner's showing with respect to Payne. *See generally* PO Resp.; PO Sur-Reply.

i.

First, Patent Owner contends that "Dr. Blalock admitted that, to determine whether a dopant concentration gradient would 'aid carrier movement,' he looked *only* at the direction of the slope" and "did not look at

the magnitude of the slope or other possible forces acting on a carrier." PO Resp. 17–18. Citing the testimony of Dr. Glew, Patent Owner takes the position that "the magnitude of the concentration gradient plays a big role, because a small gradient may not be sufficient to overcome the resistance of the material in which the gradient exists." *Id.* at 18 (citing Ex. 2057 ¶ 51); PO Sur-reply 15 (citing Ex. 2058, 89; Ex. 2058, 137–138); *see id.* at 15–16 (citing Ex. 2057 ¶¶ 50–51).

Patent Owner further argues that "[a]s Dr. Blalock testified and Dr. Glew confirms, the magnitude of the slope is essential to determine the magnitude of the force the dopant gradient places on the carrier and thus the net force." PO Resp. 25 (citing PO Resp. § VI.A.2; Ex. 2057 ¶ 58). According to Patent Owner, "[t]he record confirms that simply grading dopants does not *guarantee* carrier movement." PO Sur-reply 1 (emphasis added); *see id.* at 2–3. Patent Owner further contends that "[i]n the absence of an express teaching that a specific gradient disclosed in the prior art is 'sufficiently graded' to 'aid carrier movement' Petitioner must show that the prior art '*necessarily* include[s] the unstated limitation.'" *Id.* at 6–7 (citing *Transclean Corp. v. Bridgewood Servs., Inc.*, 290 F.3d 1364, 1373 (Fed. Cir. 2002); Ex. 2077[7] (Western District of Texas *Markman* Order), 39–40).

According to Patent Owner, "the specification, like Greenthread's statements during prosecution, describes the slope of the dopant concentration as a relevant parameter for determining whether a concentration gradient will aid the movement of minority carriers." PO

[7] We also note that Exhibits 2077 through 2081, which were submitted by Patent Owner with its Sur-reply without prior Board authorization, were stricken. Paper 80 (Motion to Strike, "Mot. Strike").

Resp. 13–14. Patent Owner quotes the specification to support its argument: "'[t]he gradient can be linear, quasi linear, exponential or complimentary error function. The relative slope of the donor concentration throughout the base creates a suitable aiding drift electric field, to help the' carriers move." *Id.* at 14 (quoting Ex. 1001, 2:60–64); *see also* PO Sur-reply 16 (discussing disclosures of relative slope in the '222 patent specification).

Patent Owner also takes the position that Petitioner's arguments reflect a change in claim construction position. PO Sur-reply 1.

ii.

Patent Owner argues that "[t]he Petition points to Figures 10-11 of Payne for the claimed 'graded concentration of dopants' recited in limitation [44.4]," "[b]ut for the claimed 'aid the movement of carriers' feature of limitations [44.5]/[44.6], the Petition relies entirely on Greenthread's supposed admissions":

> Payne's downward-sloping graded-dopant concentration aids the movement of minority carriers from the surface layer to the substrate—more precisely, to an area of the substrate where there are no active regions, as discussed above— *to the same extent* to which Applicant relied on the prior art and admitted to the Patent Office that such carrier movement would occur under the same scenario.

PO Resp. 24 (quoting Pet. 26) (citing Pet. 37–40); *see id.* (citing Pet. 26–33; Ex. 1003 ¶¶ 95–108, 117–121). Patent Owner further argues that "Dr. Blalock admitted that he did not calculate the slope of the graded concentration curve in Payne." *Id.*

iii.

Patent Owner contends that "Petitioner cites Wang (Ex. 1013)[8] in Ground I but it is not apparent (and not clearly explained in the Petition) how Wang might be in any way relevant to Ground I (which is a single reference obviousness ground based on Payne)." PO Resp. 25. According to Patent Owner,

> [t]he Petition states that "Dr. Blalock explains that during a so-called single event upset (SEU), an α-ray generates millions of carriers, some of which are produced in or near the active regions at the surface of the substrate" and cites page 431 and Figure 2 of Wang. But the Petition has not clearly explained what [that] has to do with Payne or the Petition's analysis of Payne. The Petition's discussion of Wang should be disregarded for that reason alone.

Id. at 25–26 (citing Pet. 29–30 (citing Ex. 1013, 431, Fig. 2)). Patent Owner further contends that Petitioner has not established public availability of Wang, "which purports to be from 2008, i.e., four years after the critical date of the Challenged Patent." *Id.* at 25–26 (citing Ex. 1003 ¶¶ 18, 100; Pet. ix; Ex. 1009, 429 (listing Wang's copyright date as 2008)).

According to Patent Owner,

> Dr. Blalock did not cite any other reference or basis for his assertion that during an SEU "some [carriers] are produced in or near the active region at the surface" Therefore, the Petition contains no evidence that a POSITA would have known about

[8] Petitioner submits Exhibit 1013 (Wang and Agrawal, *Single Event Upset: An Embedded Tutorial*, 21st Int'l Conf on VLSI Design, 429–434, IEEE 2008), which explains that "soft errors" are "random and not related to permanent hardware faults" and "[t]heir causes may be internal (e.g., interconnect coupling) or external (e.g., cosmic radiation)," including "alpha particles [that] are emitted when the nucleus of an unstable isotope decays to a lower energy state." Ex. 1013, Abstract, 430.

> SEU carriers at the surface at the time of the Challenged Patent. Accordingly, the Petition cannot properly rely on Wang to demonstrate knowledge of a POSITA regarding any teachings of Payne.

Id. at 26 (citing Ex. 2057 ¶ 59; Ex. 1003 ¶ 100).

Patent Owner contends that "as explained by Dr. Glew—who has experience working with alpha-rays—a POSITA would have understood that in the context of alpha-rays, carriers are rarely created near the surface," and "[t]herefore, a POSITA would not have thought Wang relevant." PO Resp. 26–27 (citing Ex. 2057 ¶¶ 10, 60; Ex. 2060, 19:21–34 ("[T]he alpha-particle immediately after irradiation to the surface of a semiconductor body has an energy of several MeV, for example about 5 MeV, and [] accordingly, the probability of creation of electron-hole pairs is extremely low near the surface." (alteration by Patent Owner)), 20:19–22 ("[T]he amount of electrons created which adversely affect the memory action is no greater than only 10% of the stored electric charge, and thus it can be disregarded."); PO Resp. § IV.B.2).

iv.

Patent Owner takes issue with Petitioner's single reference obviousness challenge applying Payne:

> The Petition attempts to have its cake and eat it too, purportedly pursuing an obviousness ground and yet apparently contending that Payne itself discloses all the elements of the Challenged Claim. In Ground 1 of the Petition, there is no articulated reasoning with any rational underpinning supporting the legal conclusion of obviousness with respect to any limitations of the Challenged Claim, and consequently the Petition's Ground 1 analysis is deficient.

PO Resp. 28. Patent Owner further argues that Petitioner did not demonstrate a reasonable expectation of obviousness with respect to Payne:

> [T]he Petition does not analyze for Ground 1 whether a POSITA would have had a reasonable expectation of success regarding any hypothetical obviousness implementation (which the Petition does not even mention)—which is a required component of obviousness analysis even for a single-reference obviousness ground as in the Petition.

Id. at 29 (citing *In re Stepan Co.,* 868 F.3d 1342 (Fed. Cir. 2017)).

Patent Owner contends that the single reference obviousness challenge applying Payne violates Patent Owner's rights under the Administrative Procedure Act—

> Patent Owner has had to allocate its resources (word count, time, and cost) without knowing whether Ground I truly is an obviousness ground or not. Clearly, secondary considerations of nonobviousness apply only in the context of an obviousness challenge, and Patent Owner has not presented arguments/evidence regarding various other secondary considerations factors out of concern about potentially wasting words on what appears to not truly be an obviousness ground.

PO Resp. 30–34.

We note that Patent Owner, however, *does* set forth objective indicia of non-obviousness in its Patent Owner Response. *Id.* at 34–37.

4. Petitioner's Reply Arguments

Petitioner responds to Patent Owner's arguments with respect to Payne. *See generally* Pet. Reply.

i.

Petitioner contends that it "is not arguing that 'graded' means 'aided,'" and that Patent Owner "wrongly suggests that the 'aid carrier movement' limitation requires calculating the slope of a dopant

concentration, which is not disclosed in the patent, not discussed in the prosecution history, and would be inconsistent with [its] statements in district court litigation." Pet. Reply 3. Petitioner further contends that Patent Owner's "own expert, Dr. Glew confirmed . . . that graded dopant concentrations always create electric fields that always interact with carriers—which is exactly what Petitioner argues." *Id.* at 2 (citing Ex. 1052, 83:13–84:23); *see id.* (citing PO Resp. 14) (quoting Ex. 1020, 29). Petitioner further contends that "[a]s PO's expert acknowledged, the challenged claims do not require any set number of carriers to move—much less 'all minority carriers.'" *Id.* at 4 (citing Ex. 1052, 82:19–83:7).

Petitioner also argues that Patent Owner "wrongly tries to ignore the applicant's representation that a downward-sloping graded dopant concentration was known to create an 'inherent "built-in" unidirectional electric field' that sweeps carriers down into the substrate." Pet. Reply 3 (citing PO Resp. 13; Ex. 1020, 289–290).

Petitioner further takes the position that Patent Owner's statements during prosecution "do not imply that any specific magnitude or absolute value of slope is required." *Id.* at 4. Petitioner supports its contention by pointing to "the specification's statement that '[t]he ***relative*** slope of the donor concentration throughout the base creates a suitable aiding drift electric field' does not suggest any specific magnitude is required." *Id.* at 5 (quoting Ex. 1001, 2:60–64 (emphasis and alteration by Petitioner)). "Instead," Petitioner contends that "'relative' refers to the directionality of the slope (i.e., increasing or decreasing in concentration), which is consistent with the general presentation of gradient fields in Figures 5B and 5C" of the specification. *Id.* at 5.

ii.

In response to Patent Owner's *second* set of arguments, Petitioner contends that "PO mischaracterizes the Payne ground" because "[t]he Petition does not 'rel[y] entirely on Greenthread's supposed admissions' to show that the Payne ground satisfies the 'aid the movement of carriers' limitation." Pet. Reply 13 (citing PO Resp. 23). According to Petitioner, "Payne describes a downward-sloping graded dopant concentration, and there is no dispute that the graded dopant concentration will create an electric field that points in the direction required by the claims." *Id.* at 14 (citing Ex. 1052, 32:15–33:25, 56:20–62:15, 69:3–71:9, 75:15–23, 83:17–89:13, 92:2–94:1, 102:2–109:14, 109:25–116:3, 120:11–123:15, 147:4–151:15). Petitioner further contends that

> [w]hile PO insists that hypothetical forces opposing this field may exist, no such forces are identified by PO or PO's expert. There is also no requirement in the challenged claims that the graded dopant concentration is strong enough to move all carriers, or to accelerate any carrier to a specific speed, or to overcome a hypothetical resistance. The only requirement is "aid[ing] the movement of carriers" for carriers moving in the recited direction. Thus, for the reasons explained in the Petition, there is no reason to doubt that the gradient dopant concentration in Payne would result in an electric field that "aids the movement of carriers" as claimed.

Id. (citing Ex. 1052, 147:4–151:15; Pet. 24–40).

Petitioner further contends that

> Dr. Blalock correctly analyzed Payne, Sakai, and Kawagoe, and explained how those references generate electric fields that "aid carrier movement" in the claimed directions. These electric fields in turn apply a force on carriers going from one surface of a device to another. Because the direction of these electric fields aligns with the direction of carrier movement

> recited in the claims, the teachings of Payne, Sakai, and Kawagoe meet the "aid carrier movement" limitations.

Pet. Reply 2 (citing Pet. 24–40, 57–67). Petitioner contends that Patent Owner's "own expert, Dr. Glew confirmed the physics underlying Petitioner's analysis" when he "testified that 'a field will provide a force in a direction aiding [] movement in the direction of the force. **That's just basic physics**.'" *Id.* (citing Ex. 1052, 108:15–109:14) (alteration and emphasis by Petitioner).

iii.

With regard to Patent Owner's *third* set of arguments, Petitioner contends that Patent Owner's dispute with respect to Wang is unavailing because Wang is merely cited for background knowledge of a POSITA, which Petitioner further contends was confirmed by Patent Owner's own prior art, Nishizawa[9], which issued in 1995, before the earliest possible priority date of the '222 patent. Pet. Reply 14. According to Petitioner, Nishizawa "confirms that alpha-ray strikes generate some electrons in the active region, and PO's expert confirmed that alpha ray strikes from cosmic rays were well known before" the earliest possible priority date of the '222 patent. *Id.* (citing Ex. 1052, 82:6–83:7, 116:4–123:15; Ex. 2057, 25 n.4; POR, 25-26.).

iv.

Petitioner contends that Patent Owner takes issue with Payne because Petitioner did not identify any claim limitation missing from Payne. Pet. Reply 15 (citing PO Resp. 27, 29). Petitioner contends that "it is well settled

[9] U.S. Patent No. 5,384,476 issued January 24, 1995 to Nishizawa et al. (Ex. 2060, "Nishizawa").

that a disclosure that anticipates under § 102 also renders the claim invalid under § 103, for anticipation is the epitome of obviousness." *Id.* (citing *Realtime Data, LLC v. Iancu*, 912 F.3d 1368, 1373 (Fed. Cir. 2019) (internal quotations omitted, quoting *Connell v. Sears, Roebuck & Co.*, 722 F.2d 1542, 1548 (Fed. Cir. 1983)). According to Petitioner, as in *Realtime Data*, "it does not matter if Petitioner could have raised Payne [in] an anticipation ground" because "[f]inding that all claim elements are present in Payne (as the Petition shows) is a sufficient basis to find the challenged claims are obvious in view of Payne." *Id.*

Petitioner also contends that *M&K Holdings, Inc. v. Samsung Elecs. Co.*, 985 F.3d 1376 (Fed. Cir. 2021) is distinguishable, because although the petitioner in that case "expressly stated in its petition that [the prior art reference] did not disclose" a particular limitation, and the petitioner did not "assert or otherwise disclose the particular claim interpretation at issue," the Board found that the prior art reference disclosed all of the limitations at issue and invalidated the challenged claim based on anticipation. Pet. Reply 15–16 (citing *M&K Holdings, Inc.*, 985 F.3d at 1385). Accordingly, "the Court found that patent owner 'was not put on notice that the Board might find that [the prior art reference] disclosed all of the limitations in claim 3 and might invalidate claim 3 based on anticipation.'" Pet. Reply 16. Petitioner contends similar facts are not present in this proceeding because "Petition plainly asserts that Payne discloses or suggests every element of claim 44, as PO itself acknowledged." *Id.* at 16 (*comparing* Pet. 11–40 *with*, PO Resp. 28). Accordingly, Petitioner contends "PO has no basis to argue unfair surprise, lack of notice, or other prejudice, *M&K Holdings* is inapplicable." *Id.*

5. Analysis of Petitioner's Contentions and the Parties' Arguments

We have considered the cited evidence, including expert testimony, and the parties' arguments pertaining to the limitations of claim 44 that are in dispute. Below, we set forth our findings and conclusions as to those disputed issues.

i.

With regard to the parties' arguments concerning the "aid[ing] the movement of carriers from the surface layer to an area of the substrate where there are no active regions" limitation, we briefly summarize the prosecution of U.S. Patent Application No. 11/622,496, the application leading to the parent '195 patent. During prosecution, the Examiner rejected claims under the pre-AIA version of 35 U.S.C. § 112, first paragraph and found that "movement of minority carriers is affected by multiple forces and fields" and that "it does not appear that simply the presence of 'a unidirectional drift field' in itself can achieve 'drawing *all* minority carriers from said surface layer to said substrate.'" Ex. 1020, 270 (emphasis added); *see id.* at 289. Patent Owner responded with following argument:

> [A] unidirectional drift (electric) field necessarily affects all the present minority carriers in the same way - moving all minority carriers in the same direction because of the unidirectional drift due to the existence of the electric field. *See* "Physics and Technology of Semiconductor Devices," A.S. Grove, pp. 224–225, John Wiley and Sons, Inc., New York, 1st Edition 1967 ("This same electric field will then be of such direction as to aid the motion of injected holes. Thus the injected minority carriers will now move not only by diffusion but also by drift due to the existence of this electric field."). Depending on the particular slope of the graded concentration of dopant, all minority carriers are either swept "down" (from the surface layer to the substrate)

> or "up" (from the substrate to the surface layer). *See* Applicant's Figs. 5(b) and 5(c).

Id. Patent Owner further argued that the Examiner's argument that the simple presence of a "graded dopant concentration" "does not appear to ensure (without knowing the other parameters of the device) that it will draw 'all' minority carriers"

> appears to not consider that the graded dopant concentration itself creates a "built-in" electrical field that forces the movement of carriers into a particular direction, whereby the "direction" of the electrical field and the resulting direction of the carrier movement depends *solely* on the slope of the graded concentration of dopant. With regard to the existence of a "built-in" electric field created by a graded dopant density, . . . *this inherent "built-in" unidirectional electric field is the additional parameter for ensuring that all minority carriers are being moved in one direction* and which parameter the Office Action deemed to be missing from the disclosure.

Id. at 289–90 (emphases added). Also, "without conceding its position on this issue," Patent Owner amended the claims to no longer require "drawing all minority carriers," and instead, requiring that the claimed "unidirectional drift field" created by the graded concentration of dopants "aid the movement of minority carriers."[10] *Id.* at 290.

We determine that the statements made by Patent Owner during prosecution of the '195 parent patent were clear, unambiguous, and indicate that one of ordinary skill in the art need not know whether there are other

[10] The examined claims of the '195 patent application generally recited "a unidirectional drift field drawing all minority carriers from said surface layer to said substrate." Ex. 1020, 286. Patent Owner amended the claims of the '195 patent application to recite "maintain[ing] a single static unidirectional electric drift field to aid the movement of minority carriers from said surface layer to said substrate." *Id*.

"forces and fields" in an electronic device, as the mere presence of a graded dopant concentration creating a "unidirectional drift field," facing in the appropriate direction, will "aid the movement of minority carriers from" the surface layer to the substrate. Ex. 1020, 270, 289–290. The public was entitled to rely on these clear and unambiguous statements when considering the scope of the challenged claims. *Hockerson-Halberstadt v. Avia Group Int'l*, 222 F.3d 951, 957 (Fed. Cir. 2000) ("The prosecution history constitutes a public record of the patentee's representation regarding the scope and meaning of the claims, and competitors are entitled to rely on those representation when ascertaining the degree of lawful conduct, such as designing around the claim invention.").

We agree with Petitioner that, contrary to Patent Owner's arguments in this proceeding, neither the specification nor the prosecution history requires a calculation of magnitude of a slope to meet the requirements of claim 44—all that is required is a determination of relative slope as described by direction. Pet. Reply 2–3. Petitioner's arguments about the prosecution of descendent U.S. Patent Application No. 17/728,588 ("the '588 application"), an application that claims priority to both the '222 patent and the '195 patent, are similarly persuasive. During prosecution of the '588 application, Patent Owner asserted that "relative slope 'means nothing more than the fact that one side is relatively lower than the other.'" Tr. 24:19–24; Ex. 3011, 9.

Based on the complete record developed during trial, we find that Patent Owner's statements during prosecution of the '195 patent and '588 application, along with the specification of the '222 patent, support a determination that "a graded concentration curve" is enough to teach aiding

carrier movement in a particular direction. We observe, in that regard, that the inventor "did not provide the type of detail in" the '222 patent's specification that Patent Owner "now argues is necessary in [the] prior art references." *In re Epstein*, 32 F.3d 1559, 1568 (Fed. Cir. 1994).

We also find Patent Owner's arguments pointing to a portion of the specification that discloses what it regards as a "specific slope value that is necessary to 'aid the movement of minority carriers'" unavailing. PO Sur-reply 13, 16. Patent Owner points to portions of the '222 patent discloses that

> the donor dopant concentration may be 10 to 100x" at one end of the gradient *compared to the other*. The next sentence recites that "[t]he gradient can be linear, quasi linear, exponential or complimentary error function. *The relative slope* of the donor concentration throughout the base creates a suitable aiding drift electric field…." In the context of a bipolar junction transistor ("BJT"), the specification recites that "the relative doping concentrations of emitter and collector regions varies from 10^{18} to $10^{20}/cm^3$, whereas the base region is 10^{14} to $10^{16}/cm^3$.

Id. at 16 (first emphasis added) (quoting Ex. 1001, 2:54–56, 2:58–63 (emphasis added)). All of the disclosed terms are relative: "the relative doping concentrations of emitter and collector regions varies from 10^{18} to $10^{20}/cm^3$, whereas the base region is 10^{14} to $10^{16}/cm^3$." Ex. 1001, 2:54–56, 2:58–63. Further still, these concentrations are set forth with respect to a bipolar junction transistor (BJT) embodiment that is not encompassed by independent claim 44. *See* Tr. 26:1–8. In the BJT embodiment of the '222 patent, doping concentration moves carriers from emitter to collector, that is, *within* the active region. *Id.* at 25:9–16, 25:19–23. In contrast, independent claim 44 requires moving carriers *away* "from the surface layer to an area of

the substrate where there are no active regions." *Id.* at 25:17–18, 25:23–25; *cf. id.* at 65:14–66:2.

We find persuasive, Petitioner's quotation from the testimony of Patent Owner's expert, Dr. Glew—"a field will provide a force in a direction aiding [] movement in the direction of the force. **That's just basic physics**." Pet. Reply 2 (citing Ex. 1052, 83:13–84:23, 108:15–109:14) (emphasis by Petitioner). We agree with Petitioner that claim 44 does not require that movement of any particular number of carriers, let alone a need to move all the carriers. *See* Pet. Reply 12–13. We further agree that independent claim 44 is not a method claim—as Petitioner's counsel explained during the hearing:

> [Petitioner's Counsel]: We're not dealing with a method claim that has an affirmative step of aiding carrier movement. When the claims say, "one graded dopant concentration to aid carrier movement," the aid carrier movement limitation is modifying a characteristic of the graded dopant concentration.

Tr. 7:14–18.

In *ParkerVision, Inc. v. Qualcomm Inc.*, 903 F.3d 1354, 1361 (Fed. Cir. 2018), the Court held that "[a]pparatus claims cover what a device *is*, not what a device *does*." *ParkerVision*, 903 F.3d at 1361 (quoting *Hewlett-Packard Co. v. Bausch and Lomb Inc.*, 909 F.2d 1464, 1468 (Fed. Cir. 1990)). "[A] prior art reference may anticipate or render obvious an apparatus claim—depending on the claim language—if the reference discloses an apparatus that is reasonably capable of operating so as to meet the claim limitations, even if it does not meet the claim limitations in all modes of operation." *Id.* Thus, to effectively challenge claim 44, Petitioner must show "a graded concentration of dopants" that is *capable* of "aid[ing]

the movement of carriers from the surface layer to an area of the substrate where there are no active regions" as claimed. We are persuaded Petitioner has done so by showing that Payne discloses a graded concentration curve with a slope, in a particular direction, in Figures 10 and 11 of Payne, that is not only reasonably capable, but actually does, move carriers in the claimed direction.

We next address Patent Owner's arguments that, during prosecution, Patent Owner "disagreed with the Examiner's conclusion that the claim at issue there (which never issued) should be rejected, but was not disagreeing with the relevant part of the Examiner's statement" that "[a] gradient is not the only force acting on a carrier." PO Sur-reply 13–14. As to the hypothetical opposing forces that Patent Owner asserts are missing from Petitioner's analysis, neither the specification nor the prosecution history nor any of the prior art mention such forces or a need to compensate for them. We agree with Petitioner that "[t]he challenged claims also do not require the graded dopant concentration be strong enough . . . to overcome a hypothetical resistance." Pet. Reply 14.

We disagree with Patent Owner that "Petitioner must show that" these hypothetical opposing forces "would *never* overwhelm the gradient." PO Sur-reply 8. Patent Owner also argues that "[t]he fact that a reference does not explicitly discuss a force does not mean that the force is absent or that a POSITA would disregard it." *Id.* Even if "it is undisputed that [some] resistance is '*always*' present" as Patent Owner argues (*id.* (citing Ex. 1052, 146:16–18 (emphasis by Patent Owner)), we disagree with Patent Owner that "[t]o carry its burden, Petitioner must affirmatively show that the other forces are absent or the gradient is stronger" (*id.*). Here again, where the

inventor "did not provide the type of detail in his specification that" Patent Owner "now argues is necessary in" Payne, we find "that one skilled in the art would have known how to implement the features of the reference[]." *In re Epstein*, 32 F.3d at 1568.

Transclean is distinguishable from the facts at issue in the present proceeding because it concerned "anticipation by inherent disclosure" which "is appropriate only when the reference discloses prior art that must necessarily include the unstated limitation." *Transclean Corp*., 290 F.3d at 1373 (citing *Cont'l Can Co. v. Monsanto Co.*, 948 F.2d 1264, 1268–69 (Fed. Cir. 1991)). The challenges in the present proceeding, including that based on Payne, are based on obviousness, and are not based on an assertion of inherent disclosure. To the contrary, as explained above, Petitioner relies on the "capability" of a prior art device to perform a claimed function and the *express* disclosure in Payne of a graded dopant concentration that extends from the surface to the substrate. *See ParkerVision*, 903 F.3d at 1361–62.

Patent Owner does not explain, nor are we able to ascertain, any shift in Petitioner's claim construction position. PO Sur-reply 1; Mot. Strike 6–7. Instead, Petitioner's Reply arguments are directly responsive to Patent Owner's arguments in its Patent Owner Response.

ii.

In response to the parties' *second* set of arguments, we disagree with Patent Owner that Petitioner "'relies entirely on Greenthread's supposed admissions' to show that the Payne ground satisfies the 'aid the movement of carriers' limitation." Pet. Reply 13 (citing PO Resp. 23). According to Petitioner, "Payne describes a downward-sloping graded dopant concentration, and there is no dispute that the graded dopant concentration

will create an electric field that points in the direction required by the claims." *Id.* at 14 (citing Ex. 1052, 32:15–33:25, 56:20–62:15, 69:3–71:9, 75:15–23, 83:17–89:13, 92:2–94:1, 102:2–109:14, 109:25–116:3, 120:11–123:15, 147:4–151:15). Petitioner further persuasively contends that

> [t]here is also no requirement in the challenged claims that the graded dopant concentration is strong enough to move all carriers, or to accelerate any carrier to a specific speed, or to overcome a hypothetical resistance. The only requirement is "aid[ing] the movement of carriers" for carriers moving in the recited direction. Thus, for the reasons explained in the Petition, there is no reason to doubt that the gradient dopant concentration in Payne would result in an electric field that "aids the movement of carriers" as claimed.

Id. (citing Ex. 1052, 147:4–151:15; Pet. 24–40); *see also* Pet. Reply 2 (citing Pet. 24–40, 57–67).

As set forth above, Petitioner's arguments are supported by Patent Owner's "own expert, Dr. Glew, [who] confirmed the physics underlying Petitioner's analysis" when he "testified that 'a field will provide a force in a direction aiding [] movement in the direction of the force. **That's just basic physics**.'" *Id.* (citing Ex. 1052, 108:15–109:14) (second alteration and emphasis by Petitioner). Contrary to Patent Owner's view, Petitioner's arguments are supported by evidence, including the wording of the challenged claims, and do not rely exclusively on Patent Owner's admissions.

iii.

With regard to the parties' arguments concerning Wang's priority date, Petitioner contends that it "supported [its challenge] with citations to Wang" that were "known before the priority date" because the Nishizawa reference, which issued in 1995, "confirms that alpha-ray strikes generate

electrons in the active region, and PO's expert confirmed that alpha ray strikes from cosmic rays were well known before" the earliest possible priority date of the '222 patent. Pet. Reply 15 (citing Ex. 1052, 82:6–83:7, 116:4–123:15; Ex. 2057, 25, n.4; PO Resp. 25–26). Even though Wang was published four years after the earliest possible priority date of the '222 patent, Petitioner supports its contention that other evidence in the record supports the assertions for which Petitioner relied on Wang and accordingly, that the evidence relied upon would have been understood by a POSITA as of the earliest possible priority date of the '222 patent.

iv.

Petitioner contends, and we agree, that "it is well settled that a disclosure that anticipates under § 102 also renders the claim invalid under § 103, for anticipation is the epitome of obviousness." Pet. Reply 15 (citing PO Resp. 27, 29; *Realtime Data, LLC v. Iancu*, 912 F.3d 1368, 1373 (Fed. Cir. 2019) (internal quotations omitted, quoting *Connell v. Sears, Roebuck & Co.*, 722 F.2d 1542, 1548 (Fed. Cir. 1983)). Contrary to Patent Owner's arguments, Petitioner need not have chosen between applying Payne as part of an anticipation challenge, or an obviousness challenge in which a limitation or element is missing from the prior art. Petitioner's obviousness challenge applying Payne is permissible and comports with precedent. Thus, we agree, that "[f]inding that all claim elements are present in Payne (as the Petition shows) is a sufficient basis to find the challenged claims are obvious in view of Payne." Pet. Reply 15.

M&K Holdings, Inc. v. Samsung Elecs. Co., 985 F.3d 1376 (Fed. Cir. 2021) is distinguishable from the facts at issue in the present proceeding, because our findings and conclusions with respect to

Petitioner's obviousness challenge over Payne do not deviate from what Petitioner presented—that is, we do not consider an anticipation theory in opposition obviousness challenge presented by Petitioner. Patent Owner was on notice that Petitioner intended Payne to be applied in an obviousness challenge, and disclosed, taught, or suggested all of the limitations of claim 44, as Patent Owner itself acknowledged. *See* Pet. Reply 16 (*comparing* Pet. 11–40 *with*, PO Resp. 28). Accordingly, we agree with Petitioner that "PO has no basis to argue unfair surprise, lack of notice, or other prejudice, [and] *M&K Holdings* is inapplicable." *Id.*

Conclusion

In view of the foregoing and notwithstanding Patent Owner's alleged objective indicia of nonobviousness discussed below, we are persuaded that Petitioner establishes, by a preponderance of the evidence, that claim 44 is unpatentable as obvious over Payne.

E. Challenge Based on the Combination of Sakai and Kawagoe

Petitioner contends that claim 44 would have been obvious in view of the combination of Sakai and Kawagoe. Pet. 5, 40–74.

1. Sakai

Sakai "relates to . . . a CMOS, in which an isolation region between two well regions of opposite conductivity types, each including an insulated gate field effect transistor . . . , is made very small in size to make possible a high-speed operation and large scale integration." Ex. 1006, 1:7–13. According to Sakai, "[i]n a conventional device . . . , in order to prevent the punch through and short channel effect," doped regions must be placed at least "several micrometers" apart, "which makes it difficult to increase the packing density of CMOS." *Id.* at 1:26–43. To increase the packing density,

Sakai describes a process in which the CMOS is formed in "a double well structure, in which" shallow wells are formed within deep wells, and source and drain regions are formed within the shallow wells. *Id.* at 1:55–2:5.

2. Kawagoe

Kawagoe discloses a process for manufacturing a semiconductor integrated circuit device using an epitaxial wafer, i.e., a semiconductor wafer having a semiconductor single crystal epitaxial layer grown over a polished semiconductor substrate. Ex. 1007, 1:13–27, 2:31–35. According to Kawagoe, "[t]he epitaxial wafer is advantageous in that it is excellent in suppressing the soft errors and resisting to the latchup," as well as "drastically reduc[ing] the defect density of the gate insulating film" of a semiconductor integrated device. *Id.* at 1:33–40.

Kawagoe discloses various "[r]epresentative[]" processes, including processes in which the single crystal (epitaxial) layer contains an impurity of the same type and in the same concentration as the substrate body. Ex. 1007, 2:55–3:9. According to Kawagoe, the impurity concentration of the substrate body can be made higher than that of epitaxial layer "so that the resistance of the semiconductor substrate body can be relatively lowered to improve the resistance to the latchup." *Id.* at 4:1–8. Kawagoe discloses a process for manufacturing a semiconductor integrated circuit device including a step of forming a semiconductor region (well) extending below the epitaxial layer and having an impurity concentration that decreases with increasing depth below the epitaxial layer. *Id.* at 3:10–25. According to Kawagoe, the well can be used for forming a complementary Metal-Oxide-Semiconductor.Field-Effect-Transistor ("MOS.FET") circuit. *Id.* at 3:32–38.

Kawagoe describes seven embodiments, including Embodiment 1 (Ex. 1007, 6:41–12:40, Figs. 1–8) and Embodiment 4 (*id.* at 14:46–19:64, Figs. 16–25). According to Embodiment 1, a semiconductor integrated circuit device includes semiconductor substrate body 2S, epitaxial layer 2E, and gettering layer 2G. *Id.* at 6:51–56, Fig. 1. Substrate body 2S and epitaxial layer 2E are doped with p-type impurity in equal concentrations. *Id.* at 6:60–7:3, 10:51–55, 11:12–16. Embodiment 1 includes n-channel MOS.FET ("nMOS") 4N and p-channel MOS.FET ("pMOS") 4P, the latter being formed in n-well 6, which is doped with n-type impurity and extends below the epitaxial layer. *Id.* at 8:46–52, 9:32–40, 11:18–24, 11:43–50, Figs. 1, 5, 7.

According to Embodiment 4, substrate body 2S and epitaxial layer 2E are doped with p-type impurity, and the impurity concentration of substrate body 2S is higher than that of epitaxial layer 2E "to improve the resistance to the latchup." Ex. 1007, 14:64–15:6, 15:13–17, 16:16–21, 19:59–63, Fig. 17. Embodiment 4 includes p-well 6*p* formed with nMOS 4N and n-well 6*n* formed with pMOS 4P. *Id.* at 15:26–40, 17:40–18:35, Figs. 16, 21–23. In Embodiment 4, the impurity concentration in p-well 6*p* and n-well 6*n* decreases with increasing depth below the epitaxial layer. *Id.* at 15:62–16:15, 17:55–61, Fig. 17. Kawagoe discloses that the concentration gradient reduces soft errors by attracting carriers (electrons) to the substrate and preventing them from entering the p-well. *Id.* at 16:2–11.

Petitioner relies on Kawagoe Figures 17 and 23, which illustrate Embodiment 4 and are reproduced below.

FIG. 17

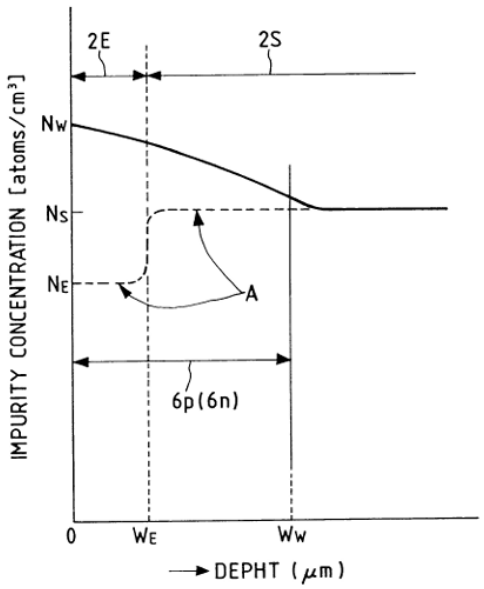

FIG. 23

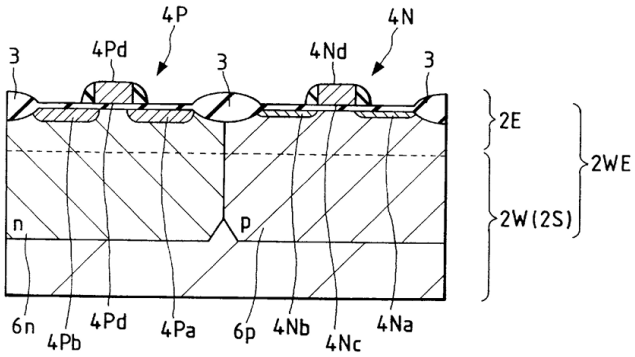

Figure 17 is a plot of impurity concentration as a function of depth in a semiconductor integrated circuit device, which shows "the p-well 6*p* and n-well 6*n* have their impurity concentrations gradually lowered in the depthwise direction from the principal surface (having an impurity concentration N_W) of the epitaxial layer 2E." Ex. 1007, 5:41–45, 15:62–16:40. Figure 23 shows a step in a process for manufacturing a semiconductor integrated circuit device, including p-well 6*p* formed with nMOS 4N and n-well 6*n* formed with pMOS 4P. *Id.* at 5:1–4, 15:26–32, 18:3–35.

3. Petitioner's Contentions

Petitioner argues that the combination of Sakai and Kawagoe would have taught or suggested the limitations of the challenged claims and that a person of ordinary skill in the art would have had reason to combine the teachings of Sakai and Kawagoe. Pet. 5, 40–74.

Reason to Combine Sakai and Kawagoe

Petitioner argues that a person of ordinary skill in the art would have had a reason to combine the teachings of Sakai with those of Kawagoe. Pet. 54–57. Petitioner argues specifically that the combination of Sakai and Kawagoe would have achieved both Sakai's benefit of improving the packing density of CMOS chips and Kawagoe's benefit of reducing soft errors. On the present record, Sakai discloses that "[i]t is an object of the present invention to provide a CMOS which is very high in packing density," and Kawagoe discloses that "the impurity concentration of" its wells "is given such a gradient that . . . the influence to be caused by the carriers (or electrons) due to the α-ray is lowered . . . so that the soft errors can be reduced." Ex. 1006, 1:55–56; Ex. 1007, 16:2–11. Petitioner cites evidence that a person of ordinary skill in the art would have known that "as geometries have been scaled down to produce circuits of greater density, alpha-particle-induced soft-error rates have also become a concern." Pet. 55; Ex. 1008B, 583. Petitioner establishes that a person of ordinary skill in the art would have had a reason to combine the teachings of Sakai with those of Kawagoe with a reasonable expectation of success.

[pre] *"[a] CMOS Semiconductor device."*

Petitioner argues that the combination of Sakai and Kawagoe teaches the preamble. Pet. 40–41. Sakai "relates to a complementary semiconductor device (hereinafter referred to as 'CMOS')." Ex. 1006, 1:6–13. Patent Owner does not contest Petitioner's evidence pertaining to the preamble of claim 44. We determine that Petitioner demonstrates by a preponderance of evidence that the combination of Sakai and Kawagoe teaches the subject

matter of the preamble of claim 44. As such, we need not and do not determine whether the preamble of claim 44 is limiting.

*[**44.1**] of claim 44 recites "a surface layer."*

Petitioner argues that the combination of Sakai and Kawagoe teaches this limitation. Pet. 41–43. Petitioner cites evidence that Sakai discloses a surface layer similar to that in the '222 patent. Pet. 42 (citing Ex. 1001, Fig. 5(b); Ex. 1003 ¶¶ 127–129; Ex. 1005, 1:28–30, 1:68–2:5, 4:25–29, 5:53–55, 5:59, 6:16–17, Fig. 10D; Ex. 1030, 6, 7, 9, 12, 13; Ex. 1033). In particular, Figure 5(b) of the '222 patent and Sakai's Figure 10D show quite similar structures, and Patent Owner identified the relevant structure in Figure 5(b) of the '222 patent as a surface layer. Ex. 1030, 7, 12.

Patent Owner does not contest Petitioner's evidence pertaining to this limitation of claim 44. We determine that Petitioner demonstrates by a preponderance of evidence that the combination of Sakai and Kawagoe teaches this limitation of claim 44.

*[**44.2**] "a substrate"*

Petitioner argues that the combination of Sakai and Kawagoe teaches this limitation. Pet. 43–45. Sakai discloses "a silicon substrate . . . made of N-silicon or P-silicon." Ex. 1006, 4:13–14.

Patent Owner does not contest Petitioner's evidence pertaining to this limitation of claim 44. We determine that Petitioner demonstrates by a preponderance of evidence that the combination of Sakai and Kawagoe teaches this limitation of claim 44.

*[**44.3**] "an active region including a source and a drain, disposed on one surface of the surface layer"*

Petitioner argues that the combination of Sakai and Kawagoe teaches this limitation. Pet. 45–48. Sakai discloses forming p-channel and n-channel

transistors, each with source and drain regions. Ex. 1006, 5:53–55, 5:64–6:4, 6:16–17, Fig. 10D. Petitioner cites evidence that a person of ordinary skill in the art would have considered the transistors to be active regions. Ex. 1001, Fig. 5(b); Ex. 1030, 6–7, 10–12; Ex. 1003 ¶¶ 133–138; Ex. 1008B, 299–300.

Patent Owner does not contest Petitioner's evidence pertaining to this limitation of claim 44. We determine that Petitioner demonstrates by a preponderance of evidence that the combination of Sakai and Kawagoe teaches this limitation of claim 44.

*[**44.4**] "a single drift layer disposed between the other surface of the surface layer and the substrate."*

Petitioner argues that the combination of Sakai and Kawagoe teaches this limitation. Pet. 48–50. Sakai discloses a deep P-well region and a deep N-well region that, on the present record, appear quite similar to the single drift layer and well region of the '222 patent. *Compare* Ex. 1003 ¶¶ 140–143; Ex. 1006, 1:57–67, 5:56–6:4, 7:32–37, Fig. 10D, *with* Ex. 1001, Fig. 5(b); Ex. 1030, 7, 11, 16.

Patent Owner does not contest Petitioner's evidence pertaining to this limitation of claim 44. We determine that Petitioner demonstrates by a preponderance of evidence that the combination of Sakai and Kawagoe teaches this limitation of claim 44.

*[**44.5**] "the drift layer having a graded concentration of dopants extending between the surface layer and the substrate, the drift layer further having a first static unidirectional electric drift field to aid the movement of carriers from the surface layer to an area of the substrate where there are no active regions."*

Petitioner argues that the combination of Sakai and Kawagoe teaches this limitation. Pet. 50–54. Sakai discloses that the dopant concentration in its shallow well regions is higher than the dopant concentration in its deep

well regions. Ex. 1003 ¶¶ 144–151; Ex. 1006, 5:56–6:4. Petitioner argues that a person of ordinary skill in the art would have understood that, because these varying dopant concentrations were "formed 'through ion implantation techniques and thermal diffusion techniques,'" the concentration would gradually decrease with increasing depth. Pet. 51 (citing Ex. 1003 ¶¶ 144–151; Ex. 1006, 5:56–6:4, 6:24–28, 6:52–58, 8:35–38). In addition, Kawagoe discloses that the wells of its CMOS device "have their impurity concentrations gradually lowered in the depthwise direction." Ex. 1007, 15:62–16:40, Figs. 17, 23.

Petitioner argues that the combination of Sakai and Kawagoe teaches this limitation. Pet. 57–61. Petitioner argues that the presence of a graded dopant concentration in the combination of Sakai and Kawagoe "creates a 'built-in' unidirectional electric drift field . . . to aid the movement of minority carriers from the surface layer to an area of the substrate where there are no active regions." Pet. 59–60 (citing Ex. 1003 ¶¶ 160–165). Sakai discloses that its active regions are located on the surface, rather than in the substrate. Ex. 1006, Fig. 10D.

Patent Owner disputes Petitioner's evidence pertaining to limitation [44.5]. We resolve the dispute about this limitation in our analysis below.

> ***[44.6]*** *"at least one well region disposed in the single drift layer, the well region having a graded concentration of dopants and a second static unidirectional electric drift field to aid the movement of carriers from the surface layer to the area of the substrate where there are no active regions."*

Petitioner argues that the combination of Sakai and Kawagoe teaches this limitation. Pet. 61–67. Petitioner contends that, in the combination of Sakai and Kawagoe, each shallow well is disposed in a single drift layer and has a graded dopant concentration. Pet. 61–63 (citing Ex. 1003 ¶¶ 169–174;

Ex. 1006, 1:57–67, 5:56–6:4, 7:32–37, Figs. 10D, 11E; Ex. 1007, 15:62–16:7). Petitioner contends that the combination of Sakai and Kawagoe satisfies this claim limitation to the same extent as the well region Patent Owner identifies in Figure 5(b) of the '222 patent. *Id.* (citing Ex. 1001, Fig. 5(b); Ex. 1030, 7). Petitioner contends that the presence of this layer creates a second "static unidirectional electric drift field that aids the movement of minority carriers from the surface layer to the area of the substrate where there are no active regions." Pet. 65–67; Ex. 1003 ¶¶ 175–178.

Patent Owner disputes Petitioner's evidence pertaining to limitation [44.6]. We resolve the dispute about this limitation in our analysis below.

4. Patent Owner's Arguments

Patent Owner disputes Petitioner's showing with respect to the combination of Sakai and Kawagoe. *See generally* PO Resp.; PO Sur-Reply.

i.

First, Patent Owner contends that the Petition fails to demonstrate that the combination of Sakai and Kawagoe teaches limitations [44.5] and [44.6] of claim 44. PO Resp. 19. Patent Owner contends that "Dr. Blalock admitted . . . that he did not calculate or consider the slope" and only focused on the direction of the slope of Kawagoe's graded dopant concentration. *Id.* at 19–20 (footnote omitted). According to Patent Owner, "Dr. Blalock admitted that the magnitude of the slope is necessary to calculate the net force on carriers, and it is the *net* force that determines carrier movement." *Id.* at 20 (citing PO Resp. § VI.A.2 (citing Ex. 2058, 89, 187–188)).

ii.

Second, Patent Owner contends "Kawagoe's concentration gradient *impedes* carrier movement." PO Resp. 20 (citing PO Resp. § VI.A.2) (bold

and underline emphasis omitted)). Patent Owner takes issue with Petitioner's truncating of a quotation from Kawagoe and, based on the complete quote from Kawagoe, contends that Kawagoe "teach[es] that the graded concentration actually *inhibits* carrier movement." *Id.* at 21. Patent Owner reproduces the quotation from Kawagoe as follows:

> Specifically, the electrons produced by the α-ray are attracted to the substrate body 2S by that concentration gradient and *prevented from entering the p-well 6p* so that the soft errors can be reduced in case the MIS memory of the DRAM or the like is formed in the p-well 6p.

Id. (quoting Ex. 1007, 16:7–11 (emphasis by Patent Owner, highlighting omitted)); *see id.* (citing Ex. 2057 ¶ 52). Instead, Patent Owner argues that

> Dr. Blalock admitted that, according to Kawagoe, SEUs generate "electrons produced in the large substrate body below the wells"—far below the surface layer. Kawagoe's electrons are ***below*** p-well 6p, and prevented from moving ***upward*** into p-well 6p. Kawagoe's 6p extends to the very top of the device. Therefore, carriers travelling vertically could only enter 6p from below.

Id. at 22 (citing Ex. 2057 ¶ 54; Ex. 2076 ¶ 94, n.6) (footnote omitted); *see id.* (citing Ex. 2057 ¶ 53). According to Patent Owner, "[a] force also cannot push in one direction and 'aid movement' in the opposite direction." PO Sur-reply 2. Patent Owner further argues that "Petitioner does not dispute Dr. Glew's . . . testimony that 'if two forces are acting on an object in opposite directions, both forces cannot aid its movement.'" PO Resp. 15–16 (citing Ex. 2057 ¶¶ 50–51). Patent Owner further contends,

> Dr. Glew confirms (citing Nishizawa) that Kawagoe is discussing carriers outside the surface layer. Nishizawa explicitly states that that probability carriers from an alpha ray at the top of a device is "extremely low" and any such carriers can be "disregarded."

PO Resp. 22–23, n.11 (citing Ex. 1046, 29).

iii.

Third, Patent Owner further contends that "[a]s explained by Dr. Glew—who has experience working with alpha rays/alpha particles—a POSITA would have understood that in the context of alpha-rays, carriers are rarely created near the surface." PO Resp. 26–27 (citing Ex. 2057 ¶¶ 10, 60; Ex. 1007, 16:7–11; Ex. 2060, 19:21–34 ("the alpha-particle immediately after irradiation to the surface of a semiconductor body has an energy of several MeV, for example about 5 MeV, and that, accordingly, ***the probability of creation of electron-hole pairs is extremely low near the surface***" (emphasis by Patent Owner)), 20:19–22 ("[T]he amount of electrons created which adversely affect the memory action is no greater than only 10% of the stored electric charge, and thus it can be disregarded.")). Based on this understanding, Patent Owner contends that, "[t]herefore, a POSITA would not have thought Wang relevant." *Id.* at 27 (citing PO Resp. § IV.B.2 (discussing Wang); Ex. 2057 ¶ 60).

Instead, Patent Owner argues that "Dr. Glew confirms (citing Nishizawa) that Kawagoe is discussing carriers outside the surface layer" and "Nishizawa explicitly states that that probability of carriers from an alpha ray at the top of a device is 'extremely low' and any such carriers can be 'disregarded.'" PO Resp. 22, n. 11 (citing Ex. 1046, 29).

iv.

Fourth, Patent Owner also argues that "[a]ll of Kawagoe's (purported) teachings about a gradient that 'aids carrier movement' refer to gradients and carriers *outside the active region*." PO Sur-reply 9 (emphasis added). According to Patent Owner, "[t]he carriers Kawagoe discusses are

'prevented from entering the wp-well,' and are thus below it." *Id.* (citing Paper 46, 21). Patent Owner further contends that "Dr. Glew testified that Kawagoe only describes that this dopant gradient is able to keep SEU electrons out of the well,' and says nothing about drawing carriers '*from* the . . . active regions.'" *Id.* at 9–10 (citing Ex. 1052, 121:11–17, 122:6–9). Patent Owner also argues that "Petitioner offers no analysis of Kawagoe's electric field to show that it has the same effect in the active region as further down." *Id.* at 10.

In its Sur-reply, Patent Owner contends that Petitioner advances a new claim construction and that it could not cross-examine Petitioner's expert, Dr. Blalock, on a rebuttal declaration because he did not submit one. PO Sur-Reply 1. Patent Owner further contends that "[t]he Western District of Texas said that "the graded concentration has to be *sufficiently graded*' to create the electric field that will cause movement and that 'a graded concentration...that is [not "sufficiently graded"] will not' 'aid movement.'" *Id.* at 4 (citing Ex. 2077, 39–40) (footnote omitted). Petitioner also contends that, "[i]n another decision, the Eastern District of Texas said that 'the slope [of the gradient] has both *a direction and a magnitude* and [d]efendant [*incorrectly*] suggests that *the direction* of the drift electric field depends solely on the direction of the slope of the graded concentration." *Id.* at 4–5 (citing *Greenthread, LLC v. Samsung Elecs. Co.*, 2020 WL 1911200, at *9 (E.D. Tex. Apr. 20, 2020) (Ex. 2079)).

5. Petitioner's Reply Arguments

Petitioner responds to Patent Owner's arguments with respect to the combination of Sakai and Kawagoe. *See generally* Pet. Reply.

i.

Petitioner contends that its "arguments relating to 'aid the movement of carriers' do not rely on an assertion that 'graded' means 'aided.'" Pet. Reply 1 (citing PO Resp. 12) (footnote omitted). Petitioner takes the position that

> the Petition and Dr. Blalock correctly analyzed Payne, Sakai, and Kawagoe, and explained how those references generate electric fields that "aid the movement of carriers" in the claimed directions. These electric fields in turn apply a force on carriers going from one surface of a device to another. Because the direction of these electric fields aligns with the direction of carrier movement recited in the claims, the teachings of Payne, Sakai, and Kawagoe meet the "aid the movement of carriers" limitations.

Id. at 1–2 (citing Pet. 24–40, 57–67). Petitioner contends that "PO wrongly suggests that the 'aid the movement of carriers' limitation requires calculating the slope of a dopant concentration, which is not disclosed in the patent, not discussed in the prosecution history, and would be inconsistent with PO's statements in district court litigation." *Id.* at 3.

ii.

In response to Patent Owner's *second* set of arguments, Petitioner responds that Patent Owner's

> argument that Kawagoe only teaches "using a graded slope to *impede* carrier movement" is incomprehensible. As PO's expert Dr. Glew admitted, whether an electric field from a graded dopant concentration aids movement or impedes movement ***depends on the direction of the movement***. It, thus, makes no sense to say an electric field would impede all movement (nor aid all movement): any given electric field will aid electron movement in one direction and impede electron movement in the opposite direction.

Id. at 6 (citing PO Resp. 14–15; Ex. 1052, 83:13–89:13, 92:2–97:8, 102:2–109:14, 109:25–116:3, 121:19–123:15).

Citing Kawagoe's teaching that "electrons produced by the α-ray are attracted to the substrate body 2S by that concentration gradient and prevented from entering the p-well," Petitioner contends that this "means an electric field aids carrier movement 'to the substrate body 2S' and impedes carrier movement in the opposite direction from 'entering the p-well.'" *Id.* (citing Ex. 1007, 16:2–11, Figs. 17, 23).

iii.

With regard to Patent Owner's *third* set of arguments, Petitioner further contends that

> [w]ithout expert support, PO also wrongly states in footnote 11 that Kawagoe's concentration gradient would prevent carriers ***above*** well region 6p from entering the well. This is wrong and contrary to the testimony of PO's own expert. As shown in Figures 17 and 23 . . . (and confirmed by Dr. Glew), the graded concentration in Kawagoe consistently decreases from the surface to the substrate, which means the resulting electric field points in the same downward direction above and below well 6p.

Pet. Reply 10–11 (citing PO Resp. 22; Ex. 1007, Figs. 17, 23; Ex. 1052, 110:18–116:3).

Petitioner further contends that "[b]ecause there are electrons in the active region of Kawagoe—regardless of any alpha ray strikes—PO's discussion of alpha rays is largely irrelevant." *Id.* at 12 (citing PO Resp. 22–27). Petitioner argues that "Petitioner referenced Kawagoe's discussion of alpha rays because it illustrates features of the electric field generated by the graded dopant concentration in Kawagoe, but that electric field exists

regardless of whether an alpha ray strike ever occurs." *Id.* Pointing to Nishizawa, Petitioner further contends

> Nishizawa says after an alpha ray strike "several ten thousand electrons will flow into the n+ type region 13," which is part of the active region. Because the challenged claims do not require a specific number or portion of electrons, it does not matter whether more electrons are also created in the substrate—an alpha ray strike still creates thousands of electrons in the relevant region.[] Additionally, Nishizawa discloses various examples—which PO ignores—where an alpha ray strike actually generates the majority of electron-hole pairs at a depth closer to a device's "top-most surface," contradicting PO's assertion that the probability of generating electron-hole pairs in this area would be "extremely low."

Id. at 12–13 (citing Ex. 2060, 19:41–42, 19:54–20:11; Figs. 34–36; Ex. 1052, 82:6–83:7, 116:4–123:15, 123:17–128:11; PO Resp., 22–27) (footnote omitted)).

6. Analysis of Petitioner's Contentions and the Parties' Arguments

We have considered the cited evidence, including expert testimony, and the parties' arguments pertaining to the limitations of claim 44 that are in dispute. Below, we set forth our findings and conclusions as to those disputed issues.

i.

With regard to the parties' arguments concerning the "aid[ing] the movement of carriers from the surface layer to an area of the substrate where there are no active regions" limitation, for substantially the same reasons set forth above in Section II.D.5, Patent Owner's arguments are unavailing. That is, no particular magnitude or specific numerical value of slope must be shown in order to satisfy claim 44. Petitioner demonstrates that the combination of Sakai and Kawagoe teach the relative slope encompassed by

the scope of independent claim 44. Our reasoning above, presented in the context of the ground based on Payne, applies with equal force here with respect to the challenge applying Sakai and Kawagoe.

ii.

As to the parties' arguments concerning whether Kawagoe discloses aiding or inhibiting the movement of carriers, Petitioner persuasively argues that it is inaccurate to assert that "an electric field would impede all movement" *or* would "aid all movement." Pet. Reply 6. We agree with Petitioner that an "electric field will aid electron movement in one direction and impede electron movement in the opposite direction." *Id.* (citing Ex. 1052, 83:13–89:13, 92:2–97:8, 102:2–109:14, 109:25–116:3, 121:19–123:15); *see id.* (citing Ex. 1007, 16:2–11, Figs. 17, 23). We determine that Patent Owner's expert, Dr. Glew, also agrees. Ex. 1052, 103:25–104:4, 104:14–16, 105:22–106:6. Thus, we agree with Petitioner that Kawagoe's disclosure that "electrons produced by the α-ray are attracted to the substrate body 2S by that concentration gradient and prevented from entering the p-well," means an electric field aids carrier movement 'to the substrate body 2S' and impedes carrier movement in the opposite direction 'entering the p-well.'" Pet. Reply 6 (citing Ex. 1052, 83:13–89:13, 92:2–97:8, 102:2–109:14, 109:25–116:3, 121:19–123:15; Ex. 1007, 16:2–11, Figs. 17, 23).

With respect to Patent Owner's argument that "Petitioner does not dispute Dr. Glew's . . . testimony that 'if two forces are acting on an object in opposite directions, both forces cannot aid its movement,'" we determine that this is not the relevant inquiry. PO Sur-reply 2 (citing Ex. 2057, 29). Patent Owner's litigation position is more on point: "Electric drift fields are a well-known phenomenon that cause carriers to move, and a POSITA

would have readily recognized that when a 'static unidirectional electric drift field' is present that it aids the movement of the minority carriers. If it isn't present, then it doesn't." Ex. 1030, 26 (Patent Owner's Responsive Claim Construction Brief in a related litigation, *supra* § I.C). Patent Owner's litigation position is also that "[t]he drift field points to one direction and charge carriers, when free to move, respond to the drift field by moving in *one direction or the other depending on their charge polarity*." *Id.* at 27 (emphasis added). More particularly, Patent Owner contends in the related litigation that

> Defendants argue that the claims do not recite a range of doping, a particular doping profile, or a particular result. But this is not the test for indefiniteness. While the claims require that the graded dopants create an electric field that aids movement of the carriers, *they do not require a specific range of doping, a particular doping field, or a particular result, and this information is not necessary to understand the scope of Dr. Rao's invention*.

Id. at 28 (emphasis added). Thus, Patent Owner's arguments in this proceeding are unavailing and are inconsistent with positions taken during related litigation.

iii.

With regard to the parties' arguments concerning alpha ray strikes, we are persuaded by Petitioner's arguments that Kawagoe's disclosure that "electrons [are] produced by the α-ray" is illustrative to show how Kawagoe discloses how the graded dopant concentration performs. Even assuming, *arguendo*, that Patent Owner is correct that "the alpha-particle immediately after irradiation to the surface of a semiconductor body has an energy of several MeV" and "the probability of creation of electron-hole pairs is

extremely low near the surface" (PO Resp. 26–27 (citing Ex. 2057 ¶ 60; Ex. 2060, 19:21–34, 20:19–22) (emphasis omitted)), we agree with Petitioner that alpha ray strikes are not even required for the Kawagoe's graded dopant concentration to create an electric field that will have an effect on a carrier depending on its charge polarity. Pet Reply 12 (citing Ex. 2060, 19:41–42, Figs. 34–36); *see id.* at 13 (citing Ex. 2060, 19:54–20:11).

Further still, Patent Owner's own evidence, namely, Nishizawa, does not support its position—Nishizawa discloses that

> [t]he number of electron-hole pairs which are created in that portion of semiconductor region up to a depth of about 0.8 μm from the surface of the semiconductor body is about 1/50 or less of the total number (which is of the order of 10^6) of those electron-hole pairs which are created in the semiconductor body by a single alpha-particle, where [the] alpha-particle is irradiated in a vertical direction. *In other words, several ten thousand electrons will flow into the n+ type region 13*.

Ex. 2060, 19:34–42 (emphasis added). Nishizawa further discloses that

> in case [an] alpha-particle is irradiated with an inclination there onto, the situation will become different. For example, in case an alpha-particle having an initial energy of 5 MeV impinges onto the surface of a silicon semiconductor body at an angle of incidence of 30º, this alpha-particle will enter into silicon up to a depth of 25 μm. However, the depth measured from the topmost surface of the device is 12.5 μm. Also, *as the initial energy of alpha-particle attenuates, the site at which electron-hole pairs are created in a large number will shift toward and closer to the surface of the device*.

Id. at 19:56–67 (emphasis added).

ParkerVision guides us that the relevant inquiry is whether the graded dopant concentration is *capable* of performing the claimed limitation, *not* how likely the claimed limitation is to be performed or occur. Not only is

Kawagoe's graded dopant concentration capable of creating an electric drift field absent an alpha ray strike, Petitioner persuasively points out that even if an alpha ray strike were required, Nishizawa indicates that the alpha ray strike could produce electrons near the surface of the CMOS device. *See* Pet. Reply 12–13 (citing Ex. 2060, 19:41–42, 19:54–20:11); Ex. 2060, 19:34–42, 19:56–57.

iv.

Patent Owner's arguments concerning the location of a gradient that aids carrier movement are first presented in Patent Owner's Sur-Reply. *See, e.g.,* PO Sur-reply 9 ("All of Kawagoe's (purported) teachings about a gradient that 'aids carrier movement' refer to gradients and carriers *outside the active region*." (emphasis added)), 10–11 ("Petitioner points to no evidence that Kawagoe's field is the same throughout and is not 'negated or reversed' *in the active region*. Kawagoe only discusses 'electrons produced in the large substrate body below the wells.'" (citing Pet. 21, n.7) (emphasis added)). We decline to consider these belated arguments, which properly should have been raised in Patent Owner's Response to allow Petitioner to fairly address them in its Reply.

For patent owners, arguments not raised in a patent owner response may be deemed forfeited if raised later, and the sur-reply "may only respond to arguments raised in the corresponding [petitioner] reply." 37 C.F.R. § 42.23(b). If the Board determines that a party is making untimely arguments, it may decline to consider them on the merits. That is the case here. As Patent Owner has not shown where its arguments were present in Patent Owner's Response, nor are we able to ascertain such, we discern that, based on the complete record developed during trial, due to the untimeliness

of Patent Owner's arguments, Petitioner was denied a full and fair opportunity to respond to this sixth set of arguments.

We also note that Exhibits 2077 through 2081, which were submitted by Patent Owner with its Sur-reply without prior Board authorization, were stricken. Paper 80 (Motion to Strike). We do not consider arguments based on these documents.

Conclusion

In view of the foregoing and notwithstanding Patent Owner's alleged objective indicia of nonobviousness discussed below, we are persuaded that Petitioner establishes, by a preponderance of the evidence, that claim 44 is unpatentable as obvious over the combination of Sakai and Kawagoe.

F. Objective Indicia of Non-Obviousness[11]

Patent Owner alleges that a license agreement with RPX Corp. ("RPX") ("the RPX license") that covers the patent family including the '222 patent is evidence supporting the objective indicia of nonobviousness. PO Resp. 2, 34–37. Patent Owner further argues that because the licensees, [redacted] approached Patent Owner through RPX without threat of litigation against them, the RPX license agreement is especially probative of non-obviousness. *Id.* at 34 (citing Ex. 2072). Patent Owner further argues that its invention is "part and parcel of the Greenthread's licenses because every patent in the family contains claim language relating to using graded dopants to move carriers from the active circuitry at the surface further down into the device. *Id.* at 36 (citations omitted).

[11] In Section II.F, we refer to the sealed version of the Patent Owner Response (Paper 46).

Patent Owner bears the burden of establishing that a nexus exists between the objective evidence and the claimed invention. *Fox Factory, Inc. v. SRAM, LLC*, 944 F.3d 1366, 1373 (Fed. Cir. 2019). Nexus is a legally and factually sufficient connection between the objective evidence and the claimed invention, such that the objective evidence should be considered in determining non-obviousness. *Demaco Corp. v. F. Von Langsdorff Licensing Ltd.*, 851 F.2d 1387, 1392 (Fed. Cir. 1988). "A nexus may not exist where, for example, the merits of the claimed invention were 'readily available in the prior art.'" *ClassCo, Inc. v. Apple, Inc.*, 838 F.3d 1214, 1220 (Fed. Cir. 2016) (quoting *Richdel, Inc. v. Sunspool Corp.*, 714 F.2d 1573, 1580 (Fed. Cir. 1983)). Further, "there is no nexus unless the evidence presented is 'reasonably commensurate with the scope of the claims.'" *Id.* (quoting *Rambus Inc. v. Rea*, 731 F.3d 1248, 1257 (Fed. Cir. 2013)).

Federal Circuit precedent "specifically require[s] affirmative evidence of nexus where the evidence of commercial success presented is a license" and requires that "only little weight can be attributed to [license] evidence if the patentee does not demonstrate a nexus between the merits of the invention and the licenses of record." *Iron Grip Barbell Co., v. USA Sports, Inc.*, 392 F.3d 1317, 1324 (Fed. Cir. 2004) (quoting *In re GPAC Inc.*, 57 F.3d 1573 (Fed. Cir. 1995)).

Here, Patent Owner does not expressly address the nexus requirement but it relies on the RPX license and asserts that its technique of "creating 'a drift field to sweep these unwanted minority carriers from the active circuitry at the surface into the substrate'" (PO Resp. 35 (quoting Ex. 1001, 3:52–56)) is "part and parcel" with the RPX license (*id.* at 36). As to Patent Owner's argument that the licenses evidence non-obviousness because

"moving carriers 'from the active circuitry at the surface' is missing from the prior art" (PO Resp. 36), we disagree that the relevant claim limitation ("to aid the movement of carriers from the surface layer to an area of the substrate where there are no active regions") is missing from the prior art for the reasons discussed above in Sections II.D.5. *See Tokai Corp. v. Easton Enters., Inc.*, 632 F.3d 1358, 1369 (Fed. Cir. 2011) ("If commercial success is due to an element in the prior art, no nexus exists."); *Ormco Corp. v. Align Technology, Inc.*, 463 F.3d 1299, 1312 (Fed. Cir. 2006) ("[I]f the feature that creates the commercial success was known in the prior art, the success is not pertinent.").

We have considered the RPX license and Patent Owner's argument, and find that they do not demonstrate a sufficient nexus with the challenged claims. In particular, the RPX license on its face does not refer to the claimed feature of using a graded dopant that PO asserts as "part and parcel" of all of the licensed patents, nor does it refer to any technical merits of the challenged claims. Further, Patent Owner offers no evidence that any licensee mentioned the challenged patents or the claimed feature of using a graded dopant during negotiation of the RPX license, and no information relating to [redacted] consideration of the potential exposure of their products. Without this information, we cannot assess whether [redacted] through the RPX license, acquiesced to the purported strength of the '222 patent. We find that the mere existence of the RPX license is not sufficient to show a nexus.

Even if Patent Owner were found to have shown a nexus, we decline to give significant weight to the RPX license because there is insufficient evidence to evaluate its context. Further, we do not agree with Patent Owner

that the RPX license is especially probative because [redacted] were under no apparent threat of litigation. See PO Resp. 2, 34. In any event, even if we assign some weight to the RPX license, it does not outweigh Petitioner's strong showing that the prior art teaches the claimed features, as discussed above. *See Tokai*, 632 F.3d at 1371 ("A strong case of *prima facie* obviousness . . . cannot be overcome by a far weaker showing of objective indicia of nonobviousness.").

Although Patent Owner argues that the RPX license was not motivated by a threat of litigation, and that the expense for [redacted] to litigate the challenged patents "would have been trivial" (*see* PO Resp. 35), the weight of evidence does not support those arguments. RPX markets itself as a cost-saving service that spreads litigation cost across a large network of companies and "remove[s] patents from circulation before they become costly issues." Ex. 1051, 1. RPX further markets itself as working on behalf of its clients to prevent potential litigation and associated legal defense costs and settlements. *Id.* at 3. In view of this evidence, Patent Owner's argument that [redacted] entered a license under no apparent threat of litigation is not persuasive.

Having determined that Patent Owner does not meet its burden to show a nexus between its alleged objective indicia and the challenged claims, we look to the evidence and argument regarding the remaining Graham factors, discussed above, in evaluating Petitioner's obviousness contentions as to each of the challenged claims.

Again, even if we were to give Patent Owner's evidence some weight, it would not overcome the strong case of obviousness set forth by Petitioner.

G. Timeliness of Petition Under 35 U.S.C. § 315(b)[12]

Pursuant to 35 U.S.C. § 315(b), "[a]n *inter partes* review may not be instituted if the petition requesting the proceeding is filed more than 1 year after the date on which the petitioner, real party in interest, or privy of the petitioner is served with a complaint alleging infringement of the patent." Patent Owner argues that the Petition should be dismissed because it is untimely. PO Resp. 37. In particular, Patent Owner argues Petitioner is in privity with Intel Corp. ("Intel"), and [redacted] (collectively "Licensees"), who Patent Owner asserts are time-barred under 35 U.S.C. § 315(b) and licensed under the '222 patent. *Id.* at 42–48.

Prior to institution, Patent Owner's arguments regarding privity were based on several theories, including that Petitioner and Licensees "are 'preceding and succeeding owners of' the licensed and/or infringing products," that Petitioner is a beneficiary of the Licensee's agreements related to accused products, that Petitioner's licensed sales encumber otherwise infringing articles, that Petitioners apparently indemnify the time-barred parties for custom-made products, and that Petitioner serves as an "agent" of Licensees by exercising their "have made" rights under the license. *See generally* Prelim. Resp.

The question of whether Petitioner is time-barred under § 315(b) is part of the determination of whether to institute an *inter partes* review. *See Thryve, Inc. v. Click-to-Call Tech., LP,* 590 U.S. 45, 54 (2020) ("§ 315(b) expressly governs institution and nothing more"). In our Institution Decision, we determined that Patent Owner had not provided a sufficient

[12] In Section II.G, we refer to the sealed versions of the Patent Owner Response in Paper 46 and the Preliminary Response in Paper 18.

factual basis upon which to question Petitioner's representation that it is not time barred (Inst. Dec. 21), or that Petitioner and Intel or [redacted] were privies, based on any of its theories regarding privity (*id.* at 14–21). We incorporate that analysis here, and reconsider Patent Owner's contention only to the extent it is warranted by subsequent argument and evidence.[13] *Id.* at 10–21; *see Achates Reference Publ'g. Inc. v. Apple Inc.,* 803 F.3d 652, 658 (Fed. Cir. 2015) ("The Board's reconsideration of the time-bar [in the final determination] is 'still fair[ly] characterize[ed] as part of the decision to institute.") (citations omitted).

Since our Institution Decision, the only new arguments regarding § 315(b) Patent Owner asserts are (1) control of prior litigation is not required to establish privity (PO Resp. 41–46); (2) Patent Owner had no opportunity to raise a *res judicata* defense in district court (*id.* at 46); (3) our finding that Petitioner's relationship with Intel did not create privity misallocated the § 315(b) burden of proof by requiring Patent Owner to produce evidence of Petitioner's and Intel's relationship (*id.* at 46–49); and (4) a finding in Petitioner's favor would violate Patent Owner's constitutional right to due process (*id.* at 57–60). We address these arguments below.

With regard to arguments (1)–(3), we note that Patent Owner presented these arguments in its request for Director review of our Institution Decision (Paper 37), which was summarily denied (Paper 43). Further, these arguments are not based on any evidence that was entered

[13] With certain exceptions for redacted documents, Patent Owner's exhibits 2001–2056 were entered prior to Institution and exhibits 2057–2100 were submitted during trial.

subsequent to our Institution Decision. Indeed, although Patent Owner unsuccessfully sought additional discovery relating to § 315(b) prior to our Institution Decision (Papers 8, 31), our Order denying that discovery noted that Patent Owner's "discovery requests are not narrowly tailored to discover any indemnification agreement" (Paper 31, 10), and Patent Owner did not renew or tailor its request for additional discovery during trial. In view of the denial of Director review and absence of additional evidence, we are not persuaded to reconsider Patent Owner's arguments (1)–(3).

Patent Owner's argument (4) regarding violation of its constitutional right to due process is based on denial of its opportunity to show that Petitioner's assertions as to its relationships with Licensees are untrue, and specifically, denial of its opportunity to cross-examine a witness about Petitioner's assertion it did not indemnify Intel. PO Resp. 59–60 (citing *Goldberg v. Kelly,* 397 U.S. 254, 269 (1970); *Greene v. McElroy*, 360 U.S. 474, 496 (1959)). Patent Owner argues it had no notice of evidence to support a finding for Petitioner under § 315(b), asserting as an example, "[t]he Board could only institute IPR if it found that Petitioner's customer-supplier relationships do not create privity by examining the terms of those relationships." *Id.* at 60.

Patent Owner's argument is not persuasive. As noted above, Patent Owner did not request additional discovery following entry of Petitioner's Preliminary Reply, or during trial. Because Patent Owner did not pursue discovery during trial through the regular course as our rules provide, we do not agree it has been denied due process. Further, we do not agree with Patent Owner's assertion that our determination that it did not demonstrate privity was necessarily based on examining the terms of Petitioner's

customer relationships. *See* PO Resp. 47, 59–60. As explained in our Institution Decision, a manufacturer-customer relationship does not necessarily suggest a privity relationship, and because Petitioner's sales to Intel are licensed (as Patent Owner acknowledges), they do not support privity. Inst. Dec. 14–15. Thus, we need not, and did not, rely on any representation from Petitioner's counsel regarding indemnification. Inst. Dec. 16–18 (noting that Patent Owner directed us to no evidence tending to support the existence of an indemnification obligation). The record thus demonstrates Patent Owner's argument that it was denied an opportunity to examine evidence underlying our Institution Decision lacks support.

III. CONCLUSION

In summary:

Claim(s)	35 U.S.C. §	Reference(s)/ Basis	Claim(s) Shown Unpatentable	Claim(s) Not Shown Unpatentable
44	103(a)	Payne	44	
44	103(a)	Sakai, Kawagoe	44	
Overall Outcome			44	

IV. ORDER

For the reasons given, it is

ORDERED that Petitioner has established, by a preponderance of evidence, that challenged claim 44 of the '222 patent is unpatentable as obvious under 35 U.S.C. § 103(a);

FURTHER ORDERED that, in view of the motions to seal, this Decision is filed "Board and Parties Only";

FURTHER ORDERED that, after conferring, the parties shall, within one week of this Decision, jointly submit to the Board via email to Trials@uspto.gov, a version of this Decision to be filed in the public record, with any redactions proposed by either party; and

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

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