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Paper __
Date: April __, 2025

PUBLIC VERSION

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CIRRUS LOGIC, INC. and
OMNIVISION TECHNOLOGIES, INC.
Petitioner,

v.

GREENTHREAD, LLC,
Patent Owner.

IPR2024-00016
Patent 10,510,842 B2

Before JON B. TORNQUIST, MONICA S. ULLAGADDI, and JULIA HEANEY, *Administrative Patent Judges*.

TORNQUIST, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining All Challenged Claims Unpatentable
35 U.S.C. § 318(a)
Denying Petitioner's Motion to Exclude
37 C.F.R. § 42.64(c)

I. INTRODUCTION

Cirrus Logic, Inc., OmniVision Technologies, Inc., and ams Sensors USA, Inc.[1] (collectively "Petitioner") filed a Petition requesting *inter partes* review of claims 1–18 of U.S. Patent No. 10,510,842 B2 (Ex. 1001, "the '842 patent"). Paper 1 ("Pet."). Greenthread, LLC ("Patent Owner") filed a Preliminary Response to the Petition. Paper 16 ("Prelim. Resp."). Petitioner subsequently filed a Preliminary Reply (Paper 20), and Patent Owner filed a Preliminary Sur-reply (Paper 22).

Upon review of the parties' arguments and supporting evidence, we instituted review with respect to all grounds and claims set forth in the Petition. Paper 30 ("Inst. Dec." or "Institution Decision"). After institution, Patent Owner filed a Response (Paper 45, "PO Resp."), to which Petitioner filed a Reply (Paper 52, "Pet. Reply"), and Patent Owner filed a Sur-reply (Paper 60, "Sur-reply").[2]

Petitioner relies, *inter alia*, upon two declarations from Sanjay Banerjee, Ph.D. (Ex. 1003 (original declaration); Ex. 1060 (supplemental declaration)), and Patent Owner relies upon a declaration from Alexander D. Glew, Ph.D. (Ex. 2057).

An oral hearing was held on January 28, 2025, and a transcript of the hearing is included in the record (Paper 73, "Tr.").

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[1] After the Petition was filed, original Petitioner ams Sensors USA Inc. merged into ams-OSRAM USA Inc. Paper 24 (Petitioner's Updated Mandatory Notices). On April 10, 2024, the parties filed a Joint Motion to Terminate the Proceedings as to ams-OSRAM USA Inc. (Paper 26), which we granted (Paper 28). The caption of this proceeding was updated accordingly.

[2] Papers 30, 45, 52, and 60 were filed under seal. Redacted versions are in the record at Papers 34, 47, 53, and 62, respectively.

For the reasons that follow, we conclude that Petitioner demonstrates by a preponderance of the evidence that claims 1–18 are unpatentable.

II. BACKGROUND

A. Related Matters

The parties indicate that the '842 patent is at issue in the following district court proceedings:

Greenthread, LLC v. Cirrus Logic, Inc., No. 1:23-cv-00369 (W.D. Tex. filed March 31, 2023);

Greenthread, LLC v. Texas Instruments Inc., No. 2:23-cv-00157 (E.D. Tex. filed April 6, 2023);

Greenthread, LLC v. OSRAM GmbH, No. 2:23-cv-00179 (E.D. Tex. filed April 19, 2023);

Greenthread, LLC v. ON Semiconductor Corp., No. 1:23-cv-00443 (D.Del. filed April 21, 2023);

Greenthread, LLC v. OmniVision Technologies, Inc., No. 2:23-cv-00212 (E.D. Tex. filed May 10, 2023); and

Greenthread, LLC v. Monolithic Power Systems, Inc., No. 1:23-cv-00579 (D. Del. filed May 26, 2023).

Pet. 1–2; Paper 7, 1–2 (Patent Owner's mandatory notices).

The parties further note that the '842 patent is at issue in IPR2023-01243. Pet. 2; Paper 7, 2.

B. Real Parties in Interest

Petitioner identifies itself (the two parties identified in the caption) and OSRAM GmbH, Heptagon Holding CA Inc., ams-OSRAM USA Inc., ams-OSRAM AG, and GlobalFoundries, U.S., Inc., as the real parties-in-interest. Pet. 1; Paper 24, 1 (Updated Mandatory Notices); *supra* n.1

(discussing order terminating ams-OSRAM USA Inc). Patent Owner identifies itself as the real party-in-interest. Paper 7, 1.

C. The '842 Patent

The '842 Patent issued December 17, 2019, and claims the benefit of a series of continuation applications, the earliest of which was filed September 3, 2004. Ex. 1001, codes (45), (60). The '842 patent is titled "Semiconductor Devices with Graded Dopant Regions" and "relates to all semiconductor devices and systems." *Id.* at code (54), 1:32–33.

The '842 patent explains that in bipolar junction transistors minority carriers are the principal device conduction mechanism, but notes that majority carriers also play a small but finite role in modulating the conductivity in such devices. Ex. 1001, 1:43–47. The '842 patent further explains that "[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." *Id*. at 1:55–57. According to the '842 patent, this improvement has not been implemented in most semiconductor devices, including various power MOSFETs and IGBTs, which "still use a uniformly doped 'drift epitaxial' region in the base." *Id*. at 1:57–62. The invention of the '842 patent implements a graded dopant concentration in these devices, which the '842 patent contends results in two important performance enhancements: "electrons can be swept from source to drain rapidly, while at the same time holes can be recombined closer to the n+ buffer layer," thereby improving "t_{on} and t_{off} in the same device." *Id.* at 3:38–43.

Figure 1 of the ’842 patent is reproduced below.

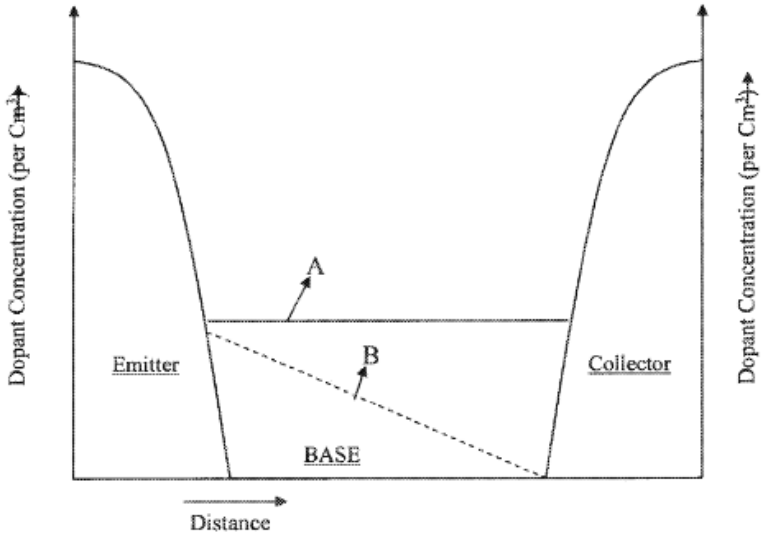


Figure 1 is labeled “Prior Art” and shows a plot of dopant concentration versus distance. Ex. 1001, Fig. 1. According to the ’842 patent, Figure 1 “illustrates the relative doping profiles of emitter, base and collector for the two most popular bipolar junction transistors: namely, uniform base (‘A’) and graded base (‘B’).” *Id.* at 2:35–38.

Figure 3A of the ’842 patent is reproduced below.

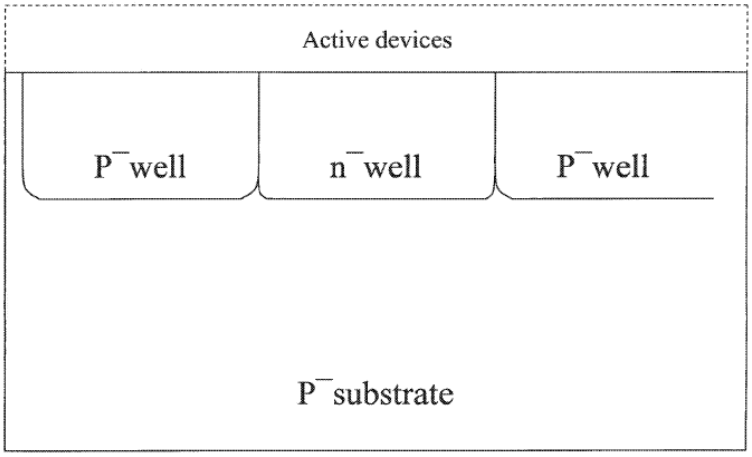
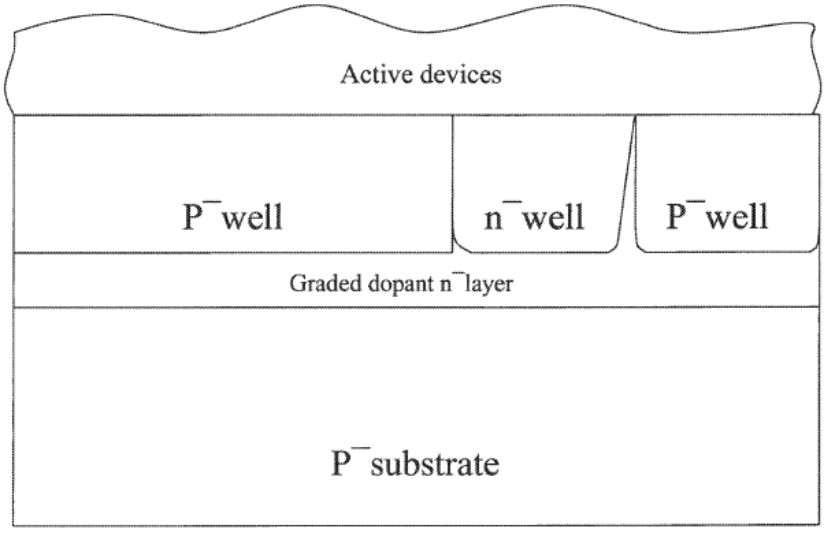


Figure 3A is labeled “Prior art (Twin well CMOS) for a CMOS integrated circuit” (“IC”), and shows a “typical” complementary metal-oxide-

semiconductor ("CMOS") very large-scale integrated circuit ("VLSI") device that employs "a twin well substrate, on which active devices are subsequently fabricated." Ex. 1001, 2:16–18, Fig. 3A; *see also id.* at 2:41–46 (explaining that Figure 3A shows a "commonly used prior art CMOS silicon substrate[]" having "a typical prior art IC with two wells (one n^-well in which p-channel transistors are subsequently fabricated and one p^-well in which n-channel transistors are subsequently fabricated)").

Figures 5A and 5B of the '842 patent are reproduced below.



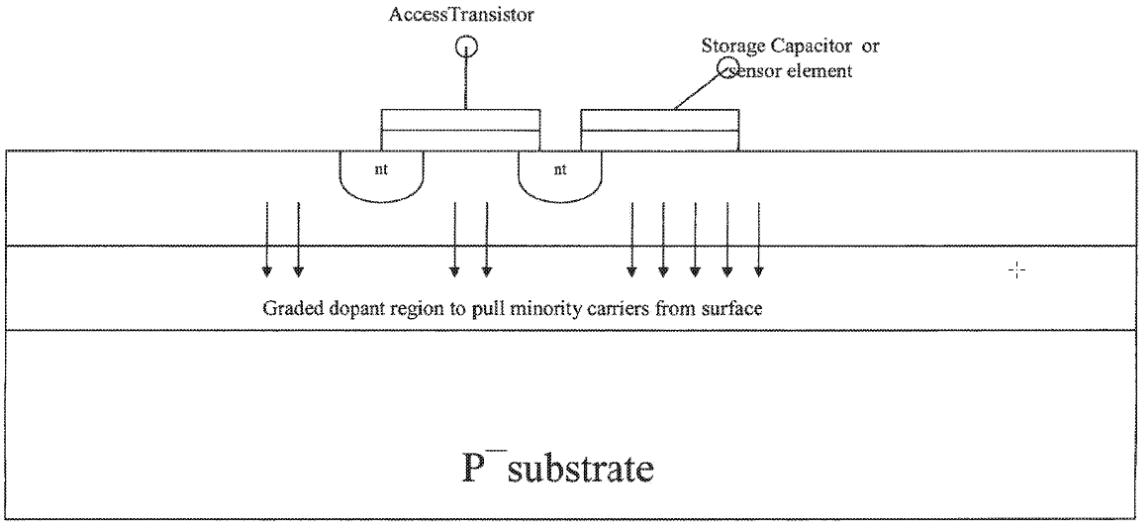


Figure 5A, the top figure, illustrates a cross section of a CMOS silicon substrate with two wells and an underlying layer using embodiments of the invention. Ex. 1001, 2:54–56. Figure 5A is labeled "[a] CMOS Substrate for digital, mixed[] signal, and sen[s]or[] IC's." Ex. 1001, Fig. 5A. The figure illustrates "a CMOS silicon substrate with two wells and an underlying layer," which is labeled "Graded dopant n^- layer," that is above a P^- substrate. *Id.* at 2:54–58, Fig. 5A. Figure 5B, below Figure 5A, depicts n-type wells in a P^- substrate and includes arrows facing downwards towards the P^- substrate and a label: "Graded dopant region to pull minority carriers from the surface." *Id.* at Fig. 5B.

The '842 patent explains that "[s]purious minority carriers can be generated by clock switching in digital VLSI logic and memory ICs" and these "unwanted carriers" degrade performance of various types of devices, including digital imaging ICs. Ex. 1001, 3:47–55. According to the '842 patent, "a novel technique is described" in which "a drift field [is used] to sweep these unwanted minority carriers from the active circuitry at the surface into the substrate in a monolithic die as quickly as possible." *Id.* at 3:60–64.

D. Illustrative Claim

Petitioner challenges claims 1–18 (all claims) of the '842 patent. Claims 1 and 9 are independent, with claim 1 illustrative of the claimed subject matter.

> 1. A semiconductor device, comprising:
>
> a substrate of a first doping type at a first doping level having first and second surfaces;
>
> a first active region disposed adjacent the first surface of the substrate with a second doping type opposite in

conductivity to the first doping type and within which transistors can be formed;

a second active region separate from the first active region disposed adjacent to the first active region and within which transistors can be formed;

transistors formed in at least one of the first active region or second active region; and

at least a portion of at least one of the first and second active regions having at least one graded dopant concentration to aid carrier movement from the first surface to the second surface of the substrate.

Ex. 1001, 4:45–60.

E. Asserted Grounds of Unpatentability

Petitioner asserts the following grounds of unpatentability (Pet. 6–7):

Claims Challenged	35 U.S.C. §[3]	Reference(s)/Basis
1–18	103(a)	Kawagoe[4]
1–18	103(a)	Kawagoe, Gupta[5]

[3] The Leahy-Smith America Invents Act ("AIA"), Pub. L. No. 112-29, 125 Stat. 284, 287–88 (2011), amended 35 U.S.C. § 103, effective March 16, 2013. Because the '842 patent has an effective filing date before that date, we refer to the pre-AIA version of § 103. Ex. 1001, code (60).

[4] Ex. 1007, US 6,043,114, issued March 28, 2000 ("Kawagoe"). Petitioner asserts that Kawagoe is prior art under 35 U.S.C. §102(b). Pet. 6.

[5] Ex. 1014, US 6,163,877, issued December 19, 2000 ("Gupta"). Petitioner asserts that Gupta is prior art under 35 U.S.C. §102(b). Pet. 6.

Claims Challenged	35 U.S.C. §[3]	Reference(s)/Basis
1–3, 5–11, 13–18	103(a)	Wieczorek,[6] Wolf[7]
1–3, 5–11, 13–18	103(a)	Wieczorek, Wolf, Gupta

III. ANALYSIS

A. Legal Standard

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

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[6] Ex. 1006, US 2003/0183856 A1, published October 2, 2003 ("Wieczorek"). Petitioner asserts that Wieczorek is prior art under 35 U.S.C. §§ 102(a), (e). Pet. 6.

[7] Ex. 1008, Stanley Wolf and Richard N. Tauber, *Silicon Processing for the VLSI Era*, Vols. 1–4, Lattice Press (2000) ("Wolf"). Petitioner asserts that Wolf was published and publicly available no later than 2002, and is prior art under 35 U.S.C. §102(b). Pet. 6 (citing Exs. 1012, 1013, 1036). Exhibit 1008 was submitted in four parts (A–D) and includes selected portions of Wolf.

B. Level of Ordinary Skill in the Art

In order to determine whether an invention would have been obvious at the time the application was filed, we consider the level of ordinary skill in the pertinent art. *Graham*, 383 U.S. at 17. In assessing 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) (quotation omitted).

Petitioner contends that a person of ordinary skill in the art ("POSITA") 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. 10 (citing Ex. 1003 ¶¶ 47–50). Petitioner further contends that "[a]dditional education might compensate for a deficiency in experience, and vice-versa." *Id.*

Patent Owner contends that a person of ordinary skill in the art would have "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." PO Resp. 5 (citing Ex. 2057 ¶¶ 17–18). According to Patent Owner, "[a]dditional education in a relevant field or industry experience may compensate for a deficit in one of the other aspects of the requirements stated above." *Id.*

Upon review of the parties' arguments and the prior art of record, we adopt Petitioner's definition of the person of ordinary skill in the art as it is

consistent with the disclosures of the '842 patent and the prior art of record. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001) (holding that the prior art itself can reflect the appropriate level of ordinary skill in the art). We note, however, that neither party asserts that the outcome of this proceeding would differ based on the minor differences between the two parties' definitions of an ordinarily skilled artisan. Nor does either party question whether the opposing party's declarant is a person of ordinary skill in the art under either proposed definition.

C. Claim Construction

In this proceeding, the claims of the '842 patent are construed "using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. [§] 282(b)." 37 C.F.R. § 42.100(b). Under that standard, the words of a claim are generally given their "ordinary and customary meaning," which is the meaning the term would have had to a person of ordinary skill at the time of the invention, in the context of the entire patent including the specification. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–13 (Fed. Cir. 2005) (en banc).

Both parties agree that express claim construction is not necessary in order to resolve the issues presented in the Petition. Pet. 10–11; PO Resp. 5–6. We note, however, that Patent Owner asks that we "clarify" that "the plain and ordinary meaning of 'aid carrier movement' requires that a carrier move in the specified direction." PO Resp. 6. Patent Owner also asserts that the "aid carrier movement" limitation cannot be met "in situations where there is no carrier movement—an absurd result." *Id.* We address these "aid carrier movement" arguments below in our discussion of the obviousness ground based on Kawagoe.

D. Objective Indicia of Non-obviousness

Objective indicia of non-obviousness, or secondary considerations of non-obviousness, serve "an important role as a guard against the statutorily proscribed hindsight reasoning in the obviousness analysis," and must be considered in every case in which they are presented. *WBIP, LLC v. Kohler Co.*, 829 F.3d 1317, 1328 (Fed. Cir. 2016). Objective indicia of non-obviousness may include evidence of a long-felt need in the art, praise within the industry, skepticism in the industry about whether or how a problem could be solved, copying, and commercial success. *Id.* at 1132–37.

To be probative of non-obviousness, Patent Owner must prove there is a nexus between the presented evidence and the merits of the claimed invention. *See Demaco Corp. v. F. Von Langsdorff Licensing Ltd.*, 851 F.2d 1387, 1392 (Fed. Cir. 1988). A rebuttable presumption of nexus applies when the "patentee shows that the asserted evidence is tied to a specific product and that the product '*is* the invention disclosed and claimed.'" *Fox Factory, Inc. v. SRAM, LLC*, 944 F.3d 1366, 1373 (Fed. Cir. 2019) (quoting *Demaco*, 851 F.2d at 1392). When the evidence relied upon is that of a license, however, we "require affirmative evidence of nexus," "because it is often 'cheaper to take licenses than to defend infringement suits.'" *Iron Grip Barbell Co., Inc. v. USA Sports, Inc.*, 392 F.3d 1317, 1324 (Fed. Cir. 2004) (quoting *EWP Corp. v. Reliance Universal Inc.*, 755 F.2d 898, 908 (Fed. Cir. 1985)).

Patent Owner contends that during its prior litigation with [redacted] RPX Corp. ("RPX") approached Patent Owner about negotiating a license for [redacted] and [redacted] PO Resp. 26 (citing Ex. 2072 (Rao Declaration)). Patent Owner contends it never threatened [redacted] or [redacted] with litigation in any way prior to the license

negotiations. *Id.* Patent Owner further contends that as part of litigation settlements at least five large, sophisticated parties have taken licenses, with eight major semiconductor companies now having paid more than $50 million for licenses to just one patent family. *Id.* at 29.

Patent Owner does not specifically address the nexus requirement, but asserts that licenses taken without threat of litigation are especially probative of non-obviousness, and contends even litigation-inspired licenses have some probative value. PO Resp. 26–27, 29 (citing *Transocean Offshore Deepwater Drilling, Inc. v. Maersk Drilling USA, Inc.*, 699 F.3d 1340, 1349 (Fed. Cir. 2012); *Fox Factory Inc. v. SRAM LLC*, IPR2017-00472, Paper 64 at 44). Patent Owner contends [redacted] and [redacted] are sophisticated companies who frequently file IPR petitions, yet both paid for licenses covering just the single patent family at issue here. *Id.* at 26–27.

Petitioner argues in its Reply that licenses that result from settlement require affirmative evidence of nexus because it is often cheaper to take a license than to defend infringement suits, and [redacted] and [redacted] licenses were made through RPX, which structures its arrangements to avoid litigation costs. Pet. Reply 27–28. Petitioner further argues that a recent license for the relevant patent family was made for a greatly reduced amount. *Id.* at 28.

Patent Owner argues in its Sur-reply that "[p]aying money for a patent license, when no litigation is threatened only makes sense if the licensee thinks the patent is valid and valuable." Sur-reply 24. Patent Owner further argues that the sales volume for the recent licensee was lower than Patent Owner's other licensees, which "confirms the value" of Patent Owner's patents. *Id.*

Patent Owner provides persuasive evidence that the patent family at issue has generated significant licensing revenue both from settlements during litigation and during direct negotiations with parties who had not been threatened with litigation. Patent Owner's evidence of nexus with respect to the '842 patent, however, is lacking.

"Where a product embodies claims from two patents, a presumption of nexus can be appropriate only if the claims of both patents generally cover the same invention." *Fox Factory*, 944 F.3d at 1377. And where objective evidence of non-obviousness is in the form of a license, we require specific evidence of a nexus between the licensing revenue and the merits of the claimed invention. *See Iron Grip Barbell*, 392 F.3d at 1324; *Demaco*, 851 F.2d at 1392.

The '842 patent is part of a family of patents related to graded dopant concentrations in transistors. Ex. 1001, code (60). The '842 patent is not terminally disclaimed to one or more of these patents and we are presented with no persuasive evidence that the patents cover essentially the same invention. *See Fox Factory*, 944 F.3d at 1377–78 (noting that the fact patent owner separately sought patent protection for different combinations of features "is alone probative of whether [the] combination of features adds up to more than an insignificant additional feature"). Nor are we presented with persuasive evidence to determine how much of the licensing activity or revenue was due to the specific subject matter recited in the challenged claims of the '842 patent. As such, Patent Owner fails to demonstrate a nexus between its substantial licensing revenue and the subject matter of the '842 patent.

Even if Patent Owner established a nexus between its licensing revenue and the merits of the '842 patent, such evidence would not outweigh

the strong evidence of obviousness presented by Petitioner. Patent Owner asserts that the innovative and "novel technique" of the patent family is creating "a drift field to sweep . . . unwanted minority carriers[8] from the active circuitry at the surface into the substrate." PO Resp. 28. For the reasons discussed below, Petitioner persuasively demonstrates that Kawagoe and Wieczorek disclose a drift field to sweep carriers from the first surface to the second surface. Thus, the allegedly novel advancement of the '842 patent is found in the prior art. *See Yita LLC v. MacNeil IP LLC*, 69 F.4th 1356, 1364 (Fed. Cir. 2023) ("But our case law makes clear that objective evidence of nonobviousness lacks a nexus if it exclusively relates to a feature that was known in the prior art—not necessarily well-known." (internal quotations and citations omitted))

For the foregoing reasons, we determine that Patent Owner's objective indicia of non-obviousness, including Patent Owner's sizable licensing revenue for the relevant patent family, is entitled to little weight due to a lack of nexus. And, even if we were to assign this evidence more weight, it would be insufficient to outweigh the strong case of obviousness set forth in the Petition.

E. Claims 1–18 in View of Kawagoe

Petitioner contends the subject matter of claims 1–18 would have been obvious over the disclosures of Kawagoe. Pet. 15–45.

[8] The claims of the '842 patent do not require sweeping unwanted "minority carriers." PO Resp. 28. Rather, the claims of the '842 patent are more broadly directed to "carrier movement." Ex. 1001, 4:57–60.

1. *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,"[9] and also has "excellent breakdown characteristics" that "drastically reduce the defect density of the gate insulating film" of a semiconductor integrated device. *Id.* at 1:33–40.

Kawagoe discloses various "representative" 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 the 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

[9] Petitioner submits Exhibit 1009 (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. 1009, Abstract, 430. Dr. Banerjee characterizes "latchup" as "a 'short-circuit' failure condition in poorly designed circuits." Ex. 1003 ¶ 77.

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 14:46–19:63, Figs. 16–25). Figure 1, reproduced below, depicts the device of Embodiment 1.

FIG. 1

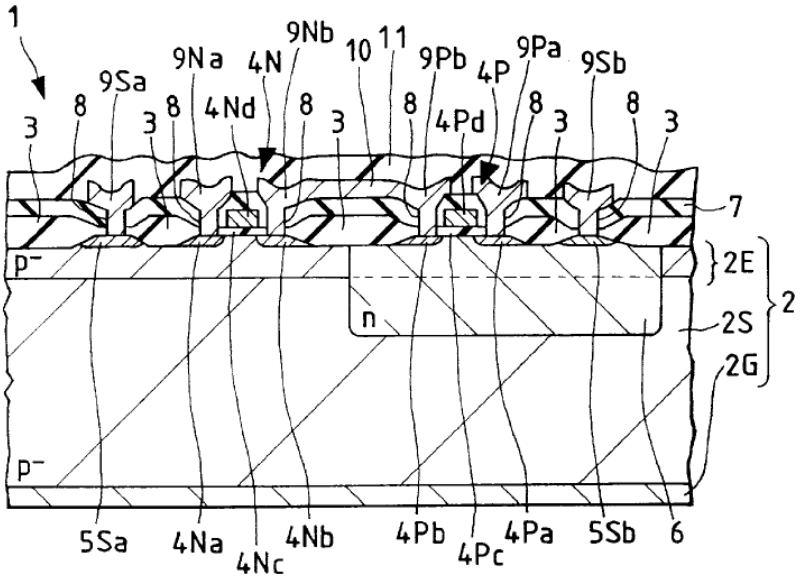


Figure 1 depicts "an essential portion of a semiconductor integrated circuit device" that includes semiconductor substrate body 2S, epitaxial layer 2E, and gettering layer 2G. *Id.* at 6:51–56, Fig. 1. Substrate body 2S and epitaxial layer 2E are doped with a p-type impurity in equal concentrations. *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.

Figure 23, reproduced below, depicts a semiconductor device of Embodiment 4 in the process of manufacture. Ex. 1007, 17:11–13.

FIG. 23

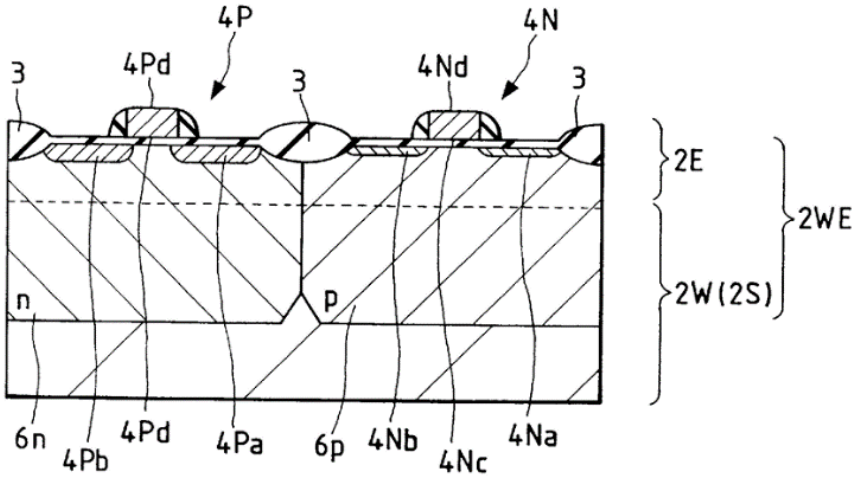


Figure 23 shows a step in a process for manufacturing the semiconductor integrated circuit device of Embodiment 4, including p-well 6*p* formed with nMOS 4N and n-well 6*n* formed with pMOS 4P. *Id.* at 6:1–4, 15:26–32, 18:3–35. In this embodiment, the impurity concentration in p-well 6*p* and n-well 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 Figure 17, which is reproduced below and illustrates properties of the semiconductor device of Embodiment 4.

FIG. 17

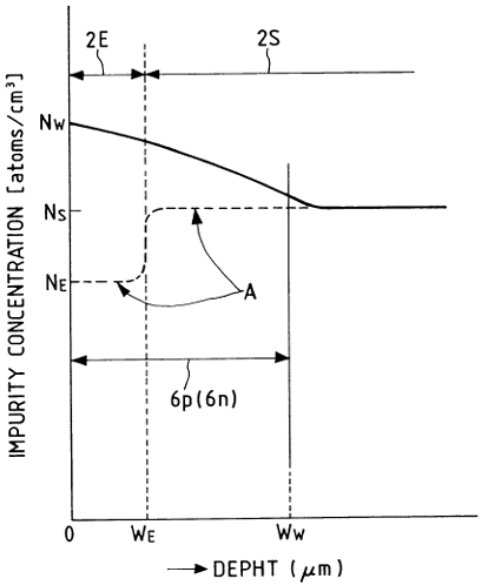


Figure 17 is a plot of impurity concentration as a function of depth in a semiconductor integrated circuit device, which shows "the p-well 6*p* and n-well 6*n* have their impurity concentrations gradually lowered in the depthwise direction from the principal surface (having an impurity concentration N_W) of the epitaxial layer 2E." Ex. 1007, 5:41–45, 15:62–16:5.

Kawagoe explains that:

> the impurity concentration of the p-well 6p is given such a gradient that it is gradually lowered in the depthwise direction from the surface of the epitaxial layer 2E, so that the influence to be caused by the carriers (or electrons) due to the α-ray is lowered. 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 6.

Ex. 1007, 16:2–11.

2. *Analysis—Independent Claim 1*

The preamble of independent claim 1 recites "A semiconductor device, comprising." Ex. 1001, 4:45. To the extent the preamble is limiting, Petitioner contends that Kawagoe discloses a "semiconductor integrated circuit device." Pet. 15 (citing Ex. 1007, 1:13–23, 14:46–67, Figs. 16, 17, 23).

Claim 1 also recites "a substrate of a first doping type at a first doping level having first and second surfaces." Ex. 1001, 4:46–47. Petitioner contends that Kawagoe discloses a "semiconductor substrate 2" having a first doping type (p-type), and that this substrate has a first surface (top) and a second surface (bottom). Pet. 16–17 (citing Ex. 1007, 6:50–56, 14:61–15:12, 17:10–18:38, Fig. 23 (as annotated by Petitioner); Ex. 1003 ¶¶ 67–68). Petitioner further contends that one of ordinary skill in the art would have sought to use the uniformly-doped epitaxial substrate of Embodiment 1 of Kawagoe, as opposed to Embodiment 4's latchup-resistant substrate, to form the twin-well CMOS device of Figure 23 because this would optimize costs over latch-up resistance, and because this substrate was shown to provide "excellent film quality" and to drastically reduce defect density. *Id.* at 18–20.

Claim 1 also recites "a first active region disposed adjacent the first surface of the substrate with a second doping type opposite in conductivity to the first doping type and within which transistors can be formed." Ex. 1001, 4:48–51. Petitioner contends that Kawagoe discloses "semiconductor regions 4Na and 4Nb" that are used "for forming the source-drain regions of the nMOS [n-channel transistor] 4N." Pet. 23 (citing Ex. 1007, 3:32–38, 8:45–52, 8:66–67, 14:46–55, 15:26–40). Petitioner further contends that source-drain regions 4Na/4Nb, in conjunction with the

channel region between these regions, form part of the claimed first active region. *Id.* at 23–24 (citing Ex. 1007, 8:46–65, 14:45–55, 15:26–40; Ex. 1003 ¶ 79; Ex. 1008B, 299–300). Petitioner further contends that regions 4Na and 4Nb are doped with a n-type impurity and therefore have a second doping type (n-type) opposite in conductivity to the first doping type (p-type) of the substrate. *Id.* at 24 (citing Ex. 1007, 8:67–9:3, 14:46–55, 15:26–40; Ex. 1003 ¶ 79). Petitioner contends that nMOS transistor 4N is formed in the claimed first active region and one of ordinary skill in the art would have sought to form multiple nMOS transistors in this region because this "would minimize chip area, as good layout practice dictates." *Id.* at 24–25 (citing Ex. 1003 ¶ 80; Ex. 1014, 1:52–54, 2:17–21).

Claim 1 also recites "a second active region separate from the first active region disposed adjacent to the first active region and within which transistors can be formed" and "transistors formed in at least one of the first active region or second active region." Ex. 1001, 4:52–56. Petitioner contends that source-drain regions 4Pa and 4Pb are part of the claimed second active region, which also includes the channel region that is between them and below gate 4Pd. Pet. 26 (citing Ex. 1007, 8:46–58, 9:41–46, 14:46–55, 15:26–40; Ex. 1008B, 299–301, Figs. 5-1, 5-2, 6-4; Ex. 1003 ¶ 83). According to Petitioner, as shown in Figure 23, pMOS transistor 4P is formed in the surface of this second active region, which is separate from and disposed adjacent to the first active region. *Id.* (citing Ex. 1007, 14:46–55; Ex. 1003 ¶ 83). Petitioner contends that either a single pMOS transistor 4P may be formed in the second active region, or one of ordinary skill in the art would have understood that multiple pMOS transistors could be formed in this region to minimize chip area. *Id.* at 27–28.

Claim 1 also recites "at least a portion of at least one of the first and second active regions having at least one graded dopant concentration to aid carrier movement from the first surface to the second surface of the substrate." Ex. 1001, 4:57–60. Petitioner contends that Figure 17 of Kawagoe illustrates the doping concentration starting from a top surface of the substrate and including the channel region and shows that the dopant concentration is "gradually lowered in the depthwise direction ***from the principal surface*** (having an impurity concentration N_W) of the epitaxial layer 2E." Pet. 28–29 (quoting Ex. 1007, 15:62–16:40, Fig. 17) (emphasis by Petitioner). According to Petitioner, the dopant concentration is thus graded in the channel region of transistor 4N, which is a portion of the first active region formed at "the principal surface" (top surface) of epitaxial layer 2E. *Id.* at 29 (citing Ex. 1003 ¶ 89). Petitioner contends the same analysis applies to the channel region of pMOS transistor 4P (a portion of the second active region). *Id.* at 30–31. Finally, Petitioner contends that, although "Figure 17 depicts the dopant concentration sloping at such a degree so as to level off" at Ns, a person of ordinary skill in the art "would have appreciated that when the device of Figure 23 is implemented using a uniformly-doped substrate as in Embodiment 1, . . . the downward slope through the p-well 6p would have the same general profile but steeper than as depicted in Figure 17." *Id.* at 30 (citing Ex. 1003 ¶ 89). Petitioner contends this graded dopant concentration would aid the movement of carriers from the first surface to the second surface. Pet. 32 (citing Ex. 1003 ¶ 92).

Patent Owner asserts that Petitioner's contentions with respect to independent claim 1 fail because (1) a graded dopant concentration does not inherently aid carrier movement; (2) the Petition fails to otherwise

demonstrate that Kawagoe discloses the "aid carrier movement" limitation; (3) the Petition fails to demonstrate that Kawagoe discloses a "first active region . . . with a second doping type opposite in conductivity to the first doping type"; and (4) objective indicia of non-obviousness establish that the challenged claims would not have been obvious. PO Resp. 13–20, 22–24, 26–29. We addressed Patent Owner's objective indicia arguments above. Below, we address the remaining arguments.

a. *Graded Dopant Concentration and Aid Carrier Movement*

1. The Parties' Arguments

Petitioner contends that Kawagoe includes a graded dopant concentration that extends from the principal surface to the substrate, as shown in Figure 17 of Kawagoe, and that Kawagoe expressly teaches that the resulting electric field will attract electrons and keep them in the substrate. Pet. 30–32 (citing Ex. 1007, 16:2–11, Figs. 17, 23; Ex. 1003 ¶¶ 89–90). Although Kawagoe discusses electrons near the surface of or inside the substrate, Petitioner presents evidence that single event upsets, such as those caused by an α-ray strike, occur in both the channel and the source/drain regions of a transistor. *Id.* at 32–33 (citing Ex. 1009, 431). In particular, Dr. Banerjee testifies that "during a so-called single event upset (SEU), an α-ray generates millions of carriers, some of which are provided in or near the active region at the top surface of the substrate." Ex. 1003 ¶ 92 (citing Ex. 1009, 431 ("A particle can induce SEU when it strikes at the channel region . . . of [a] transistor.")). When such electrons are produced in Kawagoe, Petitioner contends that the downward sloping gradient will aid the movement of such carriers from the surface to the substrate. Pet. 33–35 (citing Ex. 1003 ¶¶ 93–94).

Petitioner contends this conclusion is confirmed by the Applicant's express statements made during prosecution of a parent application and in Patent Owner's briefing before the district court. Pet. 33–35 (citing Ex. 1016, 289–290; Ex. 1020, 2, 29; Ex. 1010, 2:27–32, 5:13–27). For example, during prosecution of a parent application the Applicant presented claims requiring a "drift layer having a graded concentration of dopants extending between said surface layer and said substrate to create a unidirectional drift field drawing all minority carriers from said surface layer to said substrate." Ex. 1016, 234. These claims were rejected under 35 U.S.C. § 112, first paragraph, with the Examiner asserting that although the specification was enabling for "a unidirectional drift field," it did "not reasonably provide enablement for 'drawing all minority carriers from said substrate to said surface layer.'" *Id.* at 269. The Examiner explained that "[i]t is not clear if simply the application of 'a unidirectional drift field' is sufficient to achieve the effect of 'drawing all minority carriers from said substrate to said surface layer.'" *Id*. at 270. According to the Examiner, "[i]n a complex electronic device, movement of minority carriers is affected by multiple forces and fields . . . [and] 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.'" *Id*.

The applicant respectfully disagreed with the Examiner's assertions, stating:

> [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).

Ex. 1016, 289. In response to the Examiner's assertion 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" from the surface layer to the substrate, the Applicant asserted that this argument

> 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 (emphasis added). Along with this argument, the Applicant amended its claims to remove the requirement that the drift field "draw[] all" minority carriers from said surface layer to said substrate, and replaced it with "to aid the movement of minority carriers from said surface layer to said substrate." *Id.* at 286. The Examiner thereafter dropped the § 112, first paragraph rejection with respect to the movement or aiding the movement of carriers and, after one further set of amendments, allowed the claims. *Id.* at 301, 315, 330–334, 345–347.

Petitioner contends Patent Owner's representations before a district court are consistent with the Applicant's assertions during prosecution. Pet. Reply 6–7 (citing Ex. 1020, 25, 28; Ex. 2057 ¶ 33); Pet. 33. In that proceeding, Patent Owner's counsel stated

> Electric drift fields are a well-known phenomenon that cause carriers to move, and a [person of ordinary skill in the art] would have readily recognized that when a 'static unidirectional electric drift field' is present that it aids the movement of minority carriers. If it isn't present, then it doesn't. The claim turns on the presence of the 'unidirectional electric drift field,' and the phrase 'to aid the movement of minority carriers' merely states what the 'unidirectional electric drift field' does.

Ex. 1020, 26–27; *see also id.* at 28 ("The intrinsic record consistently confirms that electric fields aid the movement of the carriers.").

In this proceeding, Patent Owner reverses course and contends a "'graded dopant concentration' does not inherently 'aid carrier movement.'" PO Resp. 7. Patent Owner reasons that the claims require movement of carriers and there may be other forces in play within a transistor that affect such movement. *Id.* at 6–10. Consistent with the testimony of its witness, Dr. Glew, Patent Owner contends that Dr. Banerjee testified on cross-examination that carrier motion is determined by the sum of the forces acting on the carrier, or the net force. *Id.* at 7; Sur-reply 4. According to Patent Owner, Dr. Banerjee conceded that there are many different potential forces at play in a semiconductor device, such as "periodic crystalline potential," "externally applied forces or a built-in electric field," temperature, magnetic fields, the Hall effect, and forces due to the gate and gate oxide. Sur-Reply 4–5 (citing Ex. 2078, 82:9–12, 83:19–84:1, 84:16–21, 113:18–114:13, 138:11–20, 140:11–21, 183:11–20, 219:16–220:20, 222:19–22). Patent Owner contends Dr. Banerjee's and Dr. Glew's testimony is

consistent with both the Examiner's findings during prosecution and with Petitioner 30(b)(6) [10] witness, Mr. Scott Warrick, who agreed that "there's a long list of . . . physical attributes which affect the movement of carriers" and one could not tell based solely on the presence of a graded dopant concentration that the gradient would "aid carrier movement." PO Resp. 7 (citing Ex. 2056, 72:6–8, 95:2–5, 96:1–13). According to Patent Owner, Petitioner cannot interpret the claims one way when comparing them to an accused product and another way when comparing them to the prior art. *Id.* (citing *Amazon.com, Inc. v. Barnesandnoble.com, Inc.*, 239 F.3d 1343, 1351 (Fed. Cir. 2001)).

2. Analysis

Although there may be myriad forces acting upon carriers in a transistor, the Applicant made clear during prosecution that the "aid carrier movement" limitation did not require an analysis of these parameters, and the '842 patent does not mention such forces or the need to account for them. Ex. 1016, 289–290. Rather, "a unidirectional drift (electric) field necessarily affects all the present minority carriers in the same way - moving all minority carriers in the same direction" and "this inherent 'built-in' unidirectional electric field . . . ensur[es] that all minority carriers are being moved in one direction." *Id.* The public was entitled to rely upon these clear and unambiguous assertions regarding the effect of a unidirectional drift field when considering the scope of the challenged claims. *See*

[10] Pursuant to Rule 30(b)(6) of the Federal Rules of Civil Procedure, "a party may name as the deponent a public or private corporation, a partnership, an association, a governmental agency, or other entity" and the "named organization must designate one or more officers, directors, or managing agents," to testify on its behalf.

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 representations concerning 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."). Thus, evidence of a sloping dopant concentration gradient that creates a unidirectional drift field in the appropriate location and pointing in the appropriate direction is sufficient to demonstrate the "aid carrier movement" limitation of the claims. Ex. 1020, 26 (Patent Owner's counsel representing before the district court that "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.").

Patent Owner contends that the Applicant never said that all graded dopant concentrations aid carrier movement. PO Resp. 10. Patent Owner contends that if any "graded dopant concentration" would "aid carrier movement," then there was no reason to include the separate claim phrase, which strongly implies that a "'graded dopant concentration' does not inherently 'aid carrier movement.'" *Id*. We disagree. The term "to aid carrier movement from the first surface to the second surface of the substrate" is not superfluous as it indicates the direction and area in which the graded dopant concentration must aid carrier movement (from the first surface to the substrate). Thus, the use of both terms "graded" and "aided" does not imply that a "'graded dopant concentration' does not inherently 'aid carrier movement,'" as asserted by Patent Owner.

Patent Owner also contends that the Applicant's statements during prosecution have been misconstrued. PO Resp. 10–13. Patent Owner asserts that its argument during prosecution was that movement of carriers

"[d]epend[s] on the particular slope of the graded concentration of dopant[s]" and that it was responding to an Office Action regarding a claim that required a "single static unidirectional electric drift field to aid the movement of carriers," which was an "additional parameter" that ensured "that all minority carriers are moved in one direction." *Id.* at 12–13 (citing Ex. 1016, 286, 289–90).

Patent Owner's arguments are not persuasive. During prosecution the Applicant stated that "the graded dopant concentration itself creates a 'built-in' electric field that forces the movement of carrier into a particular direction," and this direction "depends solely on the slope of the graded concentration of dopant." Ex. 1016, 289–290. Thus, the graded dopant concentration creates the "additional parameter" that ensures that "all minority carriers are moved in one direction." *Id.*

Patent Owner contends "Petitioner's position that *any* gradient aids carrier movement leads to absurd results that are plainly inconsistent with the claim language." PO Resp. 8. According to Patent Owner, Petitioner's "graded" entails "aided" assumption (or claim construction) "implies that a gradient can 'aid' movement of carriers that do not move at all." *Id.* And, as noted above, Patent Owner contends that an assumption that a graded dopant concentration will necessarily aid carrier movement is inconsistent with the Examiner's assertions during prosecution, Petitioner's 30(b)(6) witness's testimony, and at least two district courts' conclusions. *Id.* at 8–9.

The Examiner's assertions and the Applicant's responses during prosecution are addressed above. Patent Owner's arguments with respect to Petitioner's 30(b)(6) witness and its arguments before the district courts are addressed below.

Testimony of Petitioner's 30(b)(6) Witness

Patent Owner contends that during the deposition of Cirrus Logic's 30(b)(6) witness, Mr. Warrick, he agreed that "there's a long list of . . . physical attributes which affect the movement of carriers" and he could not say if the downward sloping gradient of a particular accused product met the "aid carrier movement" limitation "because there's other things that might affect carrier movement besides the gradient." PO Resp. 7 (citing Ex. 2056, 72:6–8, 95:2–5, 96:1–13).

Petitioner contends Patent Owner "blatantly mischaracterizes the deposition" of Mr. Warrick, as the question Mr. Warrick was actually asked was whether "there's anything that affects the ***ease of*** carrier movement." Pet. Reply 12–14 (quoting Ex. 2056, 71:22–72:8). According to Petitioner, because other factors may affect the speed or acceleration of carrier movement, Mr. Warrick's statements did not suggest that these forces could overwhelm the drift field and preclude it from aiding carrier movement. *Id.* at 14. Petitioner also contends Patent Owner never established the "there" it was referring to, or whether the direction of the gradient was suited to aid movement "downward," let alone that Mr. Warrick understood such to be the case. *Id.* at 14.

With respect to Petitioner's 30(b)(6) testimony, we note that Mr. Warrick was testifying as a corporate representative of Cirrus Logic in the district court proceeding. Patent Owner does not contend that Mr. Warrick is one of ordinary skill in the art or that he considered the Applicant's assertions during prosecution regarding the meaning and scope of the "aid carrier movement" limitation during prosecution. Ex. 1016, 289–290. Nor does Patent Owner contend that Mr. Warrick considered Patent Owner's representations to the district court that "a [person of ordinary skill

in the art] would have readily recognized that when a 'static unidirectional electric drift field' is present that it aids the movement of minority carriers." Ex. 1020, 25–26. And, although Mr. Warrick provided a statement that is generally consistent with both Patent Owner's arguments in this proceeding and the Examiner's initial assertion during prosecution, the Applicant expressly stated during prosecution that this reasoning was incorrect in view of the scope of the claims. Ex. 1016, 289–290. As such, we find that Mr. Warrick's testimony does not evidence that a sloping dopant concentration gradient in the appropriate direction and location will not necessarily aid the movement of carriers.

The District Courts' Findings

Patent Owner contends that "two District Courts have previously agreed with [Patent Owner] that not *all* doping gradients *must* aid carrier movement." PO Resp. 9. In particular, Patent Owner contends the Western District of Texas "unequivocally stated, 'a graded concentration . . . that is [not 'sufficiently graded'] will not aid in the movement of minority carriers,'" and the Eastern District of Texas understood that direction alone does not determine whether a gradient aids carrier movement, as the magnitude of the gradient must also be considered. *Id.* (citing Ex. 2074, 39–40; Ex. 2075, 15).

Before the Western District of Texas, Petitioner (Cirrus Logic) asserted that the term "graded dopant concentration" was indefinite, as it was unclear where the boundary between "graded" and "uniform" doping concentrations would be. Ex. 2074, 32. Patent Owner argued in response that the patent provides sufficient guidance as to the meaning of the claim term, with "graded" meaning varying or not "uniform." *Id.* at 37–38 ("Greenthread contends that Figure 1 in the '195 Patent depicts the

difference between uniform and graded concentrations, namely, that the concentration in the former is the same across a region while in the latter, the concentration has a slope."). The District Court determined that the term was not indefinite for multiple reasons and that "graded" "describes a sloped doping concentration." *Id.* at 39–41. According to the court, a graded dopant concentration must be sufficiently graded to result in a "static unidirectional electric drift field to aid the movement of minority carriers," as recited in claim 1 of U.S. Patent No. 8,421,195. *Id.* at 39–40.

We discern no finding in the Court's order that one must quantify the magnitude of the field in order to know if the electric field will "aid the movement of minority carriers." First, the Court was not addressing the same argument raised by Patent Owner in this proceeding. Rather, it was addressing whether the term "graded dopant concentration" is indefinite. Second, the Court's Order can reasonably be interpreted to require only that the graded dopant concentration be sufficiently graded to create a "static unidirectional electric drift field," as recited in the claims, which, as the Applicant argued during prosecution and in its claim construction brief before the Western District of Texas, would "aid in the movement of minority carriers." Ex. 2074, 39–40; Ex. 1020, 26 ("[A person of ordinary skill in the art] would have readily recognized that when a 'static unidirectional electric drift field' is present that it aids the movement of minority carriers. If it isn't present, then it doesn't."), 28 ("The intrinsic record consistently confirms that the electric fields aid the movement of the carriers.").

Before the Eastern District of Texas, the parties disputed the proper construction of the term "single drift layer . . . having a graded concentration of dopants generating a first static unidirectional drift field." Ex. 2075, 10.

The plaintiff asserted that no construction was necessary, whereas the defendant argued that the term should be construed as a "single layer whose concentration of dopants either increases across the layer or decreases across the layer." *Id.* The Court explained that the dispute distilled into two issues: (1) whether the graded concentration of dopants could only increase or decrease; and (2) whether the "single drift layer" is necessarily a single layer. *Id.* at 13–14.

In addressing the question of whether the graded concentration of dopants could both increase and decrease in the drift layer, the Court rejected the defendant's suggestion that the prosecution statement that the direction of the electrical field and the carrier movement "depends solely on the slope of the graded concentration of dopant" demonstrates that "the slope must be only increasing or only decreasing to maintain a unidirectional drift field." *Id.* at 15. In rejecting this argument, the Court found that the Applicant (patentee) affirmatively argued during prosecution "that a graded dopant concentration will provide a unidirectional electric drift field to move the minority carriers in a single direction and *Grove*," relied upon by the Applicant during prosecution, "discloses a dopant concentration that both increases and decreases in the drift layer." *Id.* at 15–16. Contrary to Patent Owner's arguments, the Court's conclusion regarding the scope of the claims is consistent with both the Applicant's assertion during prosecution and Petitioner's arguments in this proceeding, i.e., that "a graded dopant concentration will provide a unidirectional electric drift field to move the minority carriers in a single direction." *Id.*

Conclusion

In view of the foregoing, we determine that Petitioner and the public at-large were entitled to rely upon the Applicant's statements during

prosecution that a graded dopant concentration will create a unidirectional electric drift field in a particular direction and this field will "aid carrier movement." Ex. 1016, 289–290.

b. *Carrier Movement in Kawagoe*

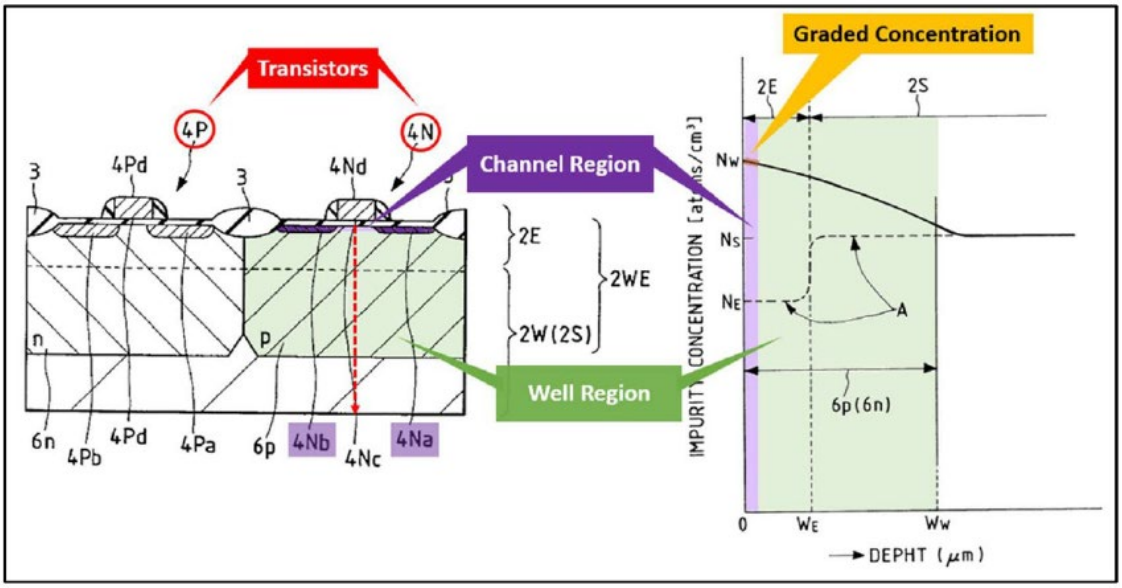
Petitioner demonstrates that Kawagoe discloses a graded dopant concentration that decreases from the top surface of the substrate towards a second surface of a substrate. Pet. 28–30. Dr. Banerjee persuasively testifies that this graded dopant concentration creates a static, unidirectional electric field that aids the movement of any carriers (electrons) present from the first surface to the second surface of the substrate. Ex. 1060 ¶¶ 21 ("In a doped semiconductor device, a graded concentration of dopants that is monotonically increasing or decreasing in a particular direction will induce a static electric drift field."), 23–24 (explaining that if the semiconductor is doped with a p-type dopant, the static electric field will point towards the surface and opposite to the direction of the slope of the graded concentration and minority carriers (electrons) will drift in a direction opposite to the direction of the electric field); Ex. 1003 ¶¶ 93–96.

Patent Owner contends that Petitioner's arguments with respect to both Kawagoe and Wieczorek fail because "it restricts its analysis to the direction of the gradient—and nothing else." PO Resp. 13. With respect to Petitioner's Kawagoe-based arguments, Patent Owner also contends these arguments are deficient because (1) the Petition fails to consider the relevant factors that affect carrier movement; (2) Kawagoe's concentration gradient actually impedes carrier movement; (3) Kawagoe's carriers are not in the active region; (4) Petitioner relies upon a post-priority date reference to make up for Kawagoe's deficiency; and (5) carriers generated by alpha-ray

strikes are not at the "surface" or in the "active regions" of semiconductor devices. We address these arguments in turn.

1. Analysis of the Relevant Factors

Petitioner persuasively demonstrates that Kawagoe discloses a downwardly sloping dopant gradient that extends from the top surface of the substrate to the bottom surface. Pet. 28–30. This is depicted in the annotated figures reproduced below:



Kawagoe's Figures 23 (left) and 17 (right) are annotated by Petitioner to show the regions in which the gradient concentration is lowered in a depthwise direction. As Figure 17 shows, the dopant concentration is "gradually lowered in the depthwise direction from the principal surface (having an impurity concentration NW) of the epitaxial layer 2E" to and through the substrate Ww. Ex. 1007, 15:67-16:2. Dr. Banerjee persuasively testifies that this graded concentration of dopants creates a static, unidirectional electric field that will apply a force on carriers (electrons) in a direction facing downwards towards the lower surface of the substrate. Ex. 1060 ¶ 21; Ex. 1003 ¶¶ 93–96. The Applicant was clear during prosecution

that such a static, unidirectional electric field will "necessarily" aid carrier movement, and other potential forces present in the transistor need not be considered. Ex. 1016, 289–290. Indeed, Dr. Glew confirmed that it is "just basic physics" that an electric field will aid movement in the direction of the force and Patent Owner has confirmed this conclusion during district court proceedings. Ex. 1069, 108:15–23 (Dr. Glew testifying that "a field will provide a force in a direction aiding – direction – aiding movement in the direction of the force. That's just basic physics."); Ex. 1020, 26 ("Electric fields are well-known phenomenon that cause carriers to move, and a [person of ordinary skill in the art] would have readily recognized that when a 'static unidirectional electric drift field' is present that it aids the movement of minority carriers.' If it isn't present, then it doesn't."). Thus, Petitioner persuasively demonstrates that Kawagoe discloses the limitation: "at least a portion of at least one of the first and second active regions having at least one graded dopant concentration to aid carrier movement from the first surface to the second surface of the substrate." Ex. 1001, 4:57–60.

To the extent other factors within the transistor were relevant to the inquiry, Patent Owner identifies no force in Kawagoe that it contends could overwhelm or negate the electric field created by the downward sloping gradient of Kawagoe. Rather, in its Response Patent Owner contends Petitioner failed to account for the inherent resistance of silicon. PO Resp. 7–8. Petitioner persuasively argues, however, that an inherent resistance may slow the movement of carriers, but it would not prevent their movement. Pet. Reply 11.

In its Sur-reply, Patent Owner identifies a series of potential forces that Dr. Banerjee testified could influence carrier movement, including three broad categories of forces (1) "periodic crystalline potential," (2) "externally

applied forces or a built-in electric field," and (3) "random forces, . . . such as lattice vibrations or static random forces due to structural defects in the crystal." PO Sur-reply 4 (citing Ex. 2078, 80:18–81:5, 82:9–12, 83:19–84:1, 84:16–21). Dr. Banerjee testified on re-direct, however, that these forces are either not mentioned in the '842 patent or would not be sufficient to overcome or negate the downward-facing electric field of Kawagoe. Ex. 2078, 319:10–22, 320:1–14.[11] Patent Owner and Dr. Glew present no persuasive evidence to suggest that these forces are present in Kawagoe, or if they are that they are sufficiently large to negate the field expressly disclosed in Kawagoe and relied upon by Dr. Banerjee. PO Resp. 7–8; PO Sur-reply 4–5. Patent Owner merely speculates that such forces might overwhelm the electric field and asserts that Dr. Banerjee did not quantify them. In addition, Kawagoe expressly discloses that carriers are prevented from entering the substrate by the electric field created by the graded dopant concentration, which appears to be strong evidence that the field is not negated by other forces in the transistor. Ex. 1007, 16:2–11.

[11] Prior to re-direct, Dr. Banerjee met with counsel for approximately 20 minutes. Ex. 2078, 339:9–20; Sur-reply 13–14. When asked if he discussed his testimony during this time, counsel instructed the witness not to answer. Ex. 2078, 339:21–340:4. As asserted by Patent Owner, this gives the appearance of improper witness coaching. *See* Sur-reply 13–14. Counsel is warned that such behavior may lead to the Board giving redirect testimony little to no weight. In this case, however, Patent Owner does not move to strike or exclude Dr. Banerjee's re-direct testimony. Moreover, Dr. Banerjee was able to clearly articulate why the three categories of forces mentioned during cross-examination would either not affect whether the electric field of Kawagoe would "aid carrier movement" or are not mentioned or contemplated in the '842 patent.

2. Impedes Carrier Movement

Kawagoe discloses that the dopant gradient is designed such that "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." Ex. 1007, 16:7–9. Patent Owner contends that this passage demonstrates that Kawagoe's graded dopant concentration actually inhibits carrier movement into the relevant area of the transistor. PO Resp. 15–16. And, "[s]ince Kawagoe teaches inhibiting carrier movement, it does not teach aiding carrier movement." *Id.* at 16.

This argument is not persuasive because whether Kawagoe's electric field aids or inhibits carrier movement simply depends on the location of the carrier. A carrier below the substrate will be inhibited from exiting the lower surface of the substrate and travelling towards the first surface of the substrate, whereas an electron carrier that exists between the first and second surfaces will be drawn by the electric field created by the graded dopant concentration towards the substrate. Pet. 31; Pet. Reply 19–20 ("In other words, aiding downwards is consistent with inhibiting movement in the opposite direction."); 1060 ¶ 21; Ex. 1003 ¶¶ 93–96.

3. Kawagoe's Carriers Are Not in the Active Region

Patent Owner contends that the carriers of Kawagoe are in the wrong place, i.e., generated below area 6p and prevented from entering it. PO Resp. 16–17. Patent Owner further contends that the evidence of record demonstrates that single-event upsets are quite rare in the channel region of a transistor. *Id.* at 18–20.

Patent Owner's arguments are not persuasive for at least two reasons. First, the challenged claims are drawn to an apparatus. *See ParkerVision, Inc. v. Qualcomm Inc.*, 903 F.3d 1354, 1361 (Fed. Cir. 2018) ("Apparatus

claims cover what a device *is*, not what a device does." (citation omitted)). Thus, Petitioner need not demonstrate actual movement of carriers in Kawagoe, only that the device is capable of moving such carriers when they are present in the active regions. *Id.* (noting that "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"); Ex. 1063, 242:2–15, 244:18–245–9 (Dr. Glew admitting that the p-well of Kawagoe has electrons present and "any electric field will act on all charged particles within its vicinity").

Second, Petitioner persuasively demonstrates that although α-ray strikes are far more common in the bulk of the substrate, they will occur in the active region of the transistor, including the channel region. Pet. 32 (citing Ex. 1003 ¶ 92; Ex. 1009, 431 ("A[n] [α-]particle can induce SEU when it strikes at the ***channel region*** of . . . [a] transistor."); Ex. 2060, 19:21–20:22; Ex. 1065, 301. Patent Owner does not appear to disagree, but presents evidence that such strikes are rare and can be discounted with respect to the behavior of the device. PO Resp. 16–17 n.4 (citing Ex. 2060, 19:21–20:22 ("[T]he probability of creation of electron-hole pairs is extremely low near the surface.")). In particular, Patent Owner points to Nishizawa's[12] disclosure that "the 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." Ex. 2060, 20:19–22. Petitioner persuasively demonstrates that the graded dopant concentration of Kawagoe will direct these carriers from the first surface to second surface of

[12] US 5,384,479, issued January 24, 1995. Ex. 2060 ("Nishizawa").

the substrate. Ex. 1060 ¶ 21; Ex. 1003 ¶¶ 93–96. That such strikes are rare is irrelevant because (1) the claims do not require actual movement of carriers, and (2) even if the claims required movement, the claims do not limit how frequently such movement must occur, i.e., frequently as opposed to very rarely.

4. Post-Priority Date Reference

Patent Owner contends that Petitioner relies upon a post-priority date reference to demonstrate that α-ray strikes will generate carriers (electrons) at the surface of the device. PO Resp. 17–18. And, because the Petition relies upon post-priority date disclosures, Patent Owner contends the "Petition contains no evidence that a POSITA would have known about SEU carriers in the active region at the time of the Challenged Patent." *Id.* at 18.

This argument is not persuasive for multiple reasons. First, the apparatus claims at issue do not require actual movement of carriers, only the capability to move such carriers if present. *See ParkerVision*, 903 F.3d at 1361. Second, Petitioner's ground is based on Kawagoe alone, and not in combination with a non-prior art reference, and Petitioner persuasively demonstrates that the fact that α-ray strikes could generate carriers in the active region of a transistor was first disclosed well-before the priority date of the '842 patent. Pet. Reply 21 (citing Ex. 1065, 301; Ex. 2060, 19:41–42, Figs. 34–36). Third, Patent Owner concedes that single-event upsets in the active region will occur, but just with a much lower probability than strikes in the bulk of the substrate. PO Resp. 19.[13] Finally, Petitioner does not

[13] Nishizawa explains that for an alpha-particle of 5 MeV, the probability of creating electron-hole pairs is extremely low near the surface, and the alpha-particle will begin to create electron-hole pairs after it has entered into the

propose changing the configuration of Kawagoe in any way based on knowledge that SEUs will occur. Thus, what a person of ordinary skill in the art would have understood about SEUs and generated carriers in the relevant time period does not affect whether Kawagoe's graded dopant concentration would aid carrier movement. Pet. Reply 21 ("Petitioner is ***not*** proposing to modify Kawagoe in view of Wang.").

5. Conclusion

For the reasons set forth above, Petitioner persuasively demonstrates that Kawagoe teaches or suggests "at least a portion of at least one of the first and second active regions having at least one graded dopant concentration to aid carrier movement from the first surface to the second surface of the substrate."[14]

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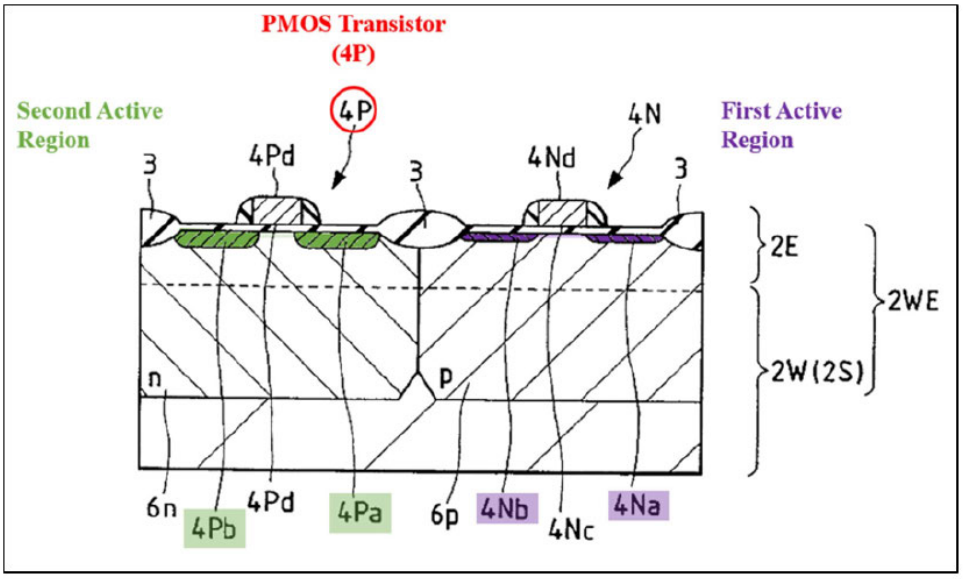
substrate a certain distance. Ex. 2060, 19:24–34. Thus, the number of electron-hole pairs in the region of the surface (to 0.8 μm from the surface) is about 1/50 or less the total number of electron hole-pairs that are created in the semiconductor body by a single alpha-particle. *Id.* at 19:34–41. Even at this reduced rate, however, "several ten thousand electrons" will flow into the active regions of the transistor from a single alpha-particle strike. *Id.* at 19:41–42. Nishizawa also explains that this number will increase when the angle of incidence is less than 90°, as this shifts electron-hole pair creation "towards and closer to the surface of the device." *Id.* at 19:58–67.

[14] During the oral hearing, Patent Owner's counsel asserted that in an NMOS the minority carriers are actually holes and the majority carriers are electrons. Tr. 61:16–23. We need not address whether this argument is correct or new, as the challenged claims only require that the "graded dopant concentration" "aid carrier movement," and it is undisputed that an electron is a carrier. Ex. 1001, 4:57–60.

c. *"first active region … with a second doping type opposite in conductivity to the first doping type"*

Claim 1 recites "first active region … with a second doping type opposite in conductivity to the first doping type." Ex. 1001, 4:48–50. Petitioner contends that Kawagoe discloses "semiconductor regions 4Na and 4Nb" that are used "for forming the source-drain regions of the nMOS [n-channel transistor] 4N." Pet. 23 (citing Ex. 1007, 3:32–38, 8:45–52, 8:66–67, 14:46–55, 15:26–40).

Annotated Figure 23 of Kawagoe is reproduced below (Pet. 27):



Referring to annotated Figure 23 above, Petitioner contends that source-drain regions 4Na/4Nb, in conjunction with the channel region, form part of the claimed first active region. *Id.* at 23–24 (citing Ex. 1007, 8:46–65, 14:45–55, 15:26–40; Ex. 1003 ¶ 79; Ex. 1008B, 299–300). Petitioner further contends that source-drain region 4Pb and 4Pa, as well as the channel region between them, constitute a second active area that is n-type. *Id.* at 26–27. Petitioner asserts that, because regions 4Na and 4Nb are doped with a n-type impurity they have a second doping type (n-type) opposite in

conductivity to the first doping type (p-type) of the substrate. *Id.* at 24 (citing Ex. 1007, 8:67–9:3, 14:46–55, 15:26–40; Ex. 1003 ¶ 79).

Patent Owner contends that Petitioner's mapping fails because the channel region between source-drain regions 4Na/4Nb is doped p-type, which is the same doping type that Petitioner identified for the first doping type of the first active region. PO Resp. 23 (citing Pet. 16, 23–24, 40).

Petitioner argues in response that Patent Owner incorrectly presumes that the claim language requires the second doping type to be distributed throughout the entire active layer. Pet. Reply 24. Petitioner contends this defies the plan language of the claim, which requires "a first active region . . . *with* a second doping type opposite in conductivity to the first doping type." *Id.* Petitioner contends its understanding is consistent with Figures 5B and 5C of the '842 patent, which Patent Owner asserted "clearly show" the "claimed invention" and depict a NMOS having n-type source and drain and a p-type substrate. *Id.* (citing PO Resp. 3–4; Ex. 1001, Figs. 5B–5C; Ex. 1060 ¶¶ 99–100). Petitioner further argues that Kawagoe's PMOS 4P is formed in an n-well and even though it is p-doped, the n-type dopants remain in the device. Pet. Reply 24–25. Thus, Petitioner contends PMOS 4P is "a first active region" having "a second doping type." *Id.* at 25.

Patent Owner argues in its Sur-reply that the "claims require that the active region have doping *opposite* to the substrate." Sur-reply 16. According to Patent Owner, the claims refer to the source and drain as a "device" and the active region as a "region," and Petitioner's understanding of the claim would render the claim language superfluous because Dr. Banerjee concludes that every active region has both n- and p-type doping. *Id.* (citing Ex. 1060 ¶ 101).

Upon review of the parties' arguments and supporting evidence, including the express disclosures of the '842 patent, we determine that Petitioner persuasively demonstrates that Kawagoe discloses a "first active region . . . with a second doping type opposite in conductivity to the first doping type." Pet. 24–26 (citing Ex. 1007, 8:46–65, 14:46–55, 15:26–40; Ex. 1003 ¶¶ 79, 81; Ex. 1008B, 299–300, Figs. 5-2, 6-4). Petitioner demonstrates that the active region of a transistor includes the source, drain, and channel region between them. *Id.* at 24. For example, Wolf's textbook states that "[t]he active regions are those in which transistor action occurs; i.e., the channel and the heavily doped source and drain regions." Ex. 1008B, 299. This first active region of Kawagoe has two types of dopants; the source and drain are doped n-type and the channel is doped p-type. Ex. 1007, Fig. 23. The first doping type identified by Petitioner is that of the p-well, or p-type dopants. Thus, the active region has "a second dopant type" (n-type) that is opposite in conductivity to the "first doping type" (p-type). We discern nothing in the language of the claim or in the written description of the '842 patent that would require that the "second dopant type" be the only type of dopant in the "first active region," and the configuration relied upon by Petitioner conforms to that depicted in Figures 5B and 5C of the '842 patent, which Patent Owner asserts disclose the claimed invention. *See* PO Resp. 4 ("The claimed invention is clearly disclosed in, e.g., Figs. 5B-5C of the Challenged Patent, and the corresponding parts of the specification."). As such, Petitioner persuasively demonstrates that Kawagoe discloses a "first active region … with a second

doping type opposite in conductivity to the first doping type," as recited in claim 1.[15] Ex. 1001, 4:48–51.

d. *Conclusion with Respect to Claim 1*

For the foregoing reasons, Petitioner persuasively demonstrates that Kawagoe teaches or suggests every limitation of claim 1 of the '842 patent. Petitioner also provides a persuasive explanation as to why one of ordinary skill in the art would have used the uniformly doped epitaxial substrate of Kawagoe as the starting material in lieu of Embodiment 4's latchup-resistant substate to form the twin-well CMOS devices of Figure 23. Pet. 20–23. And, as discussed above in Section III.D, Patent Owner's objective indicia of non-obviousness lack nexus and are entitled to little weight, but even if we gave them more weight, they would not overcome Petitioner's strong case of obviousness. Accordingly, Petitioner demonstrates by a preponderance of the evidence that claim 1 would have been obvious in view of Kawagoe.

3. *Analysis—Claim 7*

Claim 7 depends from independent claim 1 and further requires "wherein the first active region and second active region are each separated by at least one isolation region." Ex. 1001, 5:8–10.

[15] For example, there is no limitation in claim 1 that would require the first active region to have a "conductivity" that is opposite than the substrate (containing the first doping type). Rather, it is the second doping type that must be opposite in conductivity to the first doping type, and there is no dispute that the n-type dopants of the source and drain are opposite in conductivity to the p-type dopants in the channel region and p-well.

Annotated Figure 23 of Kawagoe is reproduced below:

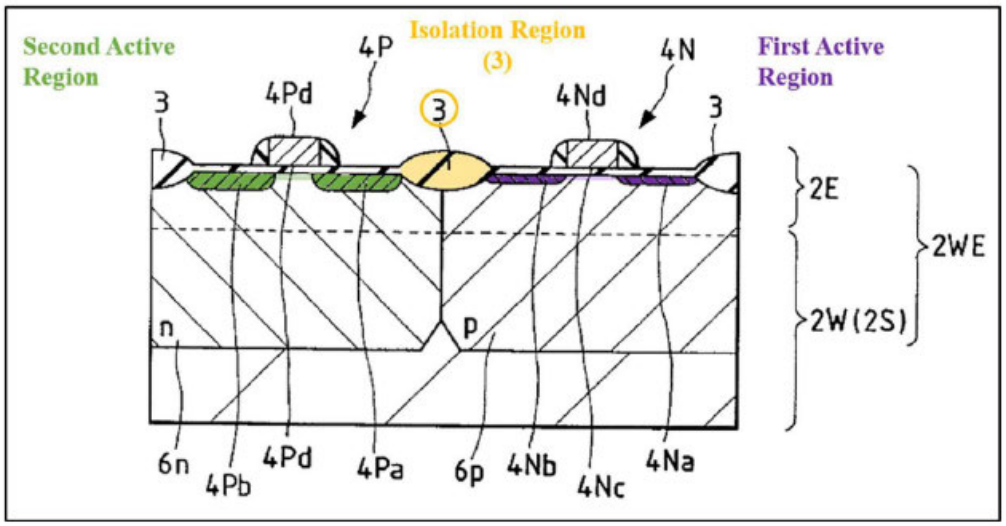


Figure 23 above contains colored annotations showing the first active region (purple), the second active region (green) and isolation region 3 (yellow). Pet. 39. Petitioner contends field insulating film 3 of Kawagoe is an isolation region that separates the first and second active regions. *Id.* (citing Ex. 1007, 8:40–52, 15:37–40, 17:62–18:8; Ex. 1008A, 818–20, Fig. 16-11(f); Ex. 1003 ¶ 103).

Patent Owner contends Petitioner fails to appreciate that regions 4Na and 4Nb "are made as deep as about 0.5 μm and formed in the range of thickness of the epitaxial layer 2E." PO Resp. 25 (quoting Ex. 1007, 9:3–6). Thus, according to Patent Owner, the first and second active regions extend to about the depth of the epitaxial layer 2E and abut each other laterally and therefore "are not separated by Kawagoe's field insulating film 3." *Id.* at 25–26 (citing 2057 ¶ 63).

As depicted in Figure 23, field insulating film 3 physically separates the first and second active regions. Ex. 1007, Fig. 23. We discern no requirement in the claims or written description that this film extend as deep as the first and second active regions. In any event, Petitioner presents

evidence that field insulating film 3 *may* extend as deep as the first and second active regions. Pet. Reply 26 (citing Ex. 1007, 8:36–40, 9:3–6, 9:47–53, 17:22–25; Ex. 1060 ¶¶ 102–103). To the extent the isolation region must be in between the first and second active regions at all points and field insulating film 3 is not so positioned, Petitioner also demonstrates that a "channel stopper region" is formed below the field insulating film and is used to ensure that errant carriers do not migrate from one transistor to another. *Id.* (citing Pet. 39; Ex. 1007, 8:43–45, 20:53–56, Fig. 26A; Ex. 1069, 142:4–143:11; Ex. 1060 ¶¶ 52, 104). Petitioner persuasively demonstrates that these two structures, in combination, also act as an isolation region. *Id.*

In view of the foregoing, Petitioner demonstrates by a preponderance of the evidence that dependent claim 7 would have been obvious in view of Kawagoe.

4. *Analysis—Dependent Claims 2–6, 8, 17, and 18*

Claims 2–6, 8, 17, and 18 all depend from independent claim 1. Petitioner identifies where Kawagoe teaches or suggests every limitation of claims 2–6, 8, 17, and 18, including a substrate that is p-type (claim 2), a substrate that is n-type (claim 3), a substrate with epitaxial silicon on top of a non-epitaxial substrate (claim 4), a first active region and second active region that contain one of either p-channel and n-channel devices (claim 5), first and second active regions that contain either p-channel or n-channel devices in n-wells or p-wells, respectively, and each well has a graded dopant (claim 6), wherein the graded dopant is fabricated with an ion implantation process (claim 8), wherein the first and second active regions are formed adjacent the first surface of the substrate (claim 17), and wherein

the transistors formed in the first and second substrates are CMOS transistors requiring a source, a drain, a gate, and a channel region (claim 18). Pet. 36–40, 43–45.

Patent Owner does not address Petitioner's contentions with respect to claims 2–6, 8, 17, and 18, apart from its arguments discussed above with respect to independent claim 1.

Upon review of the parties' arguments and supporting evidence, we find that Petitioner demonstrates by a preponderance of the evidence that claims 2–6, 8, 17, and 18 would have been obvious in view of Kawagoe.

5. *Analysis—Independent Claim 9*

Independent claim 9 mirrors the language of independent claim 1, except it requires that the first and second active regions allow transistors to "be formed in the surface thereof." Ex. 1001, 5:19–20, 5:22–23; Pet. 40–41.

Petitioner persuasively demonstrates that transistors may be formed in the surface of the first and second active regions of Kawagoe, and Patent Owner does not argue otherwise. Pet. 40–41.

Patent Owner contends the subject matter of claim 9 would not have been obvious in view of Kawagoe for the same reasons set forth above with respect to independent claim 1. PO Resp. 13–26.

Upon review of the parties' arguments and supporting evidence, we determine that Petitioner demonstrates by a preponderance of the evidence that the subject matter of claim 9 would have been obvious in view of Kawagoe.

6. *Dependent Claims 10–16*

Claims 10–16 each depend from independent claim 9. Ex. 1001, 6:1–20. The subject matter of claims 10–16 generally tracks that of dependent

claims 2–8. *Compare id.* at 4:61–13, *with id.* at 6:1–20. Petitioner contends Kawagoe discloses the subject matter of claims 10–16 for the same reasons as discussed above with respect to claims 2–8. Pet. 42–43.

Patent Owner does not address Petitioner's arguments with respect to claims 10–16, apart from its arguments regarding independent claims 1 and 9.

For the reasons set forth in the Petition, we determine that Petitioner persuasively demonstrates that Kawagoe discloses every limitation of claims 10–16. Pet. 42–43. Thus, Petitioner demonstrates by a preponderance of the evidence that claims 10–16 would have been obvious in view of Kawagoe.

7. *Conclusion*

For the reasons set forth above, Petitioner demonstrates by a preponderance of the evidence that claims 1–18 would have been obvious in view of Kawagoe.

F. Claims 1–18 in View of Kawagoe and Gupta

Petitioner contends the subject matter of claims 1–18 would have been obvious in view of the combined disclosures of Kawagoe and Gupta. Pet. 69–76.

Independent claims 1 and 9 each require an active region where transistors may be formed. Ex. 1001, 4:55–56, 5:24–25. Petitioner contends that these limitations require only evidence that a transistor may be formed in these active areas, but to the extent multiple transistors are required, this would have been obvious in view of Gupta. Pet. 69–70.

Patent Owner does not contend that Kawagoe fails to teach or suggests the "transistor" elements of independent claims 1 or 9. Thus, we

need not address Petitioner's additional arguments with respect to Kawagoe and Gupta.

G. Claims 1–3, 5–11 and 13–18 over Wieczorek and Wolf

Petitioner contends the subject matter of claims 1–3, 5–11 and 13–18 would have been obvious in view of the combined disclosures of Wieczorek and Wolf. Pet. 45–69.

1. *Wieczorek*

Wieczorek relates "to a semiconductor device, such as a field-effect transistor, having an improved retrograde dopant profile in a channel region of the transistor element." Ex. 1006 ¶ 2. Wieczorek explains that a retrograde channel dopant profile is one where "the concentration of dopants increases from the gate insulation layer to the areas located deeper down the channel region." Ex. 1006 ¶ 6. According to Wieczorek, although a retrograde channel dopant profile is desirable, it is "very difficult to obtain." *Id.* Wieczorek notes that "the dopant concentration immediately after the implantation process exhibits a desired retrograde dopant profile" (*id.* ¶ 9), but during heat treatment, "the initially retrograde profile in the vicinity of the surface of the semiconductor device . . . may have become substantially uniformly distributed" due to diffusion of the dopant atoms (*id.* ¶ 11).

Petitioner relies on Figures 1b and 2b (reproduced below), which Wieczorek uses to illustrate the prior art.

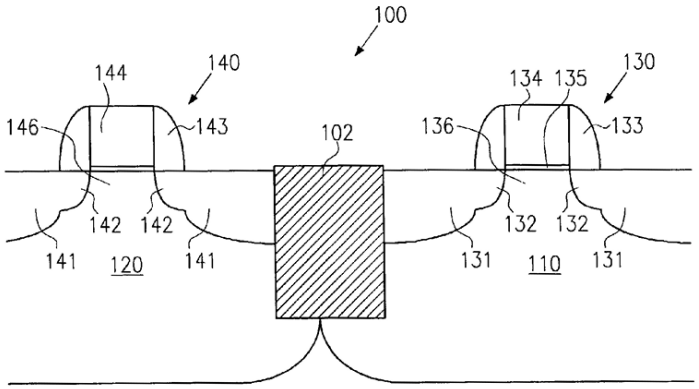


FIG.1b
(Prior Art)

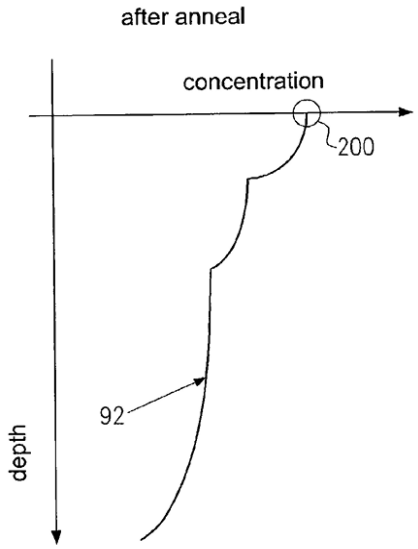


FIG.2b
(Prior Art)

Wieczorek Figure 1b shows a conventional semiconductor device at an advanced manufacturing stage. Ex. 1006 ¶¶ 12, 20. The device includes P-channel transistor 140 with source and drain regions 141 in N-well structure 120 and N-channel transistor 130 with source and drain regions 131 in P-well structure 110. *Id.* ¶ 12. Shallow trench isolation 102 separates N-well structure 120 from P-well structure 110. *Id.* ¶ 7. Wieczorek Figure 2b is a graph of dopant concentration versus depth of N-well structure 120 and P-well structure 110 and shows "a typical dopant profile with respect to the depth of the respective well structure" after ion implantation and heat treatment. *Id.* ¶¶ 9–11, 13, 21.

2. *Wolf*

Wolf is a four-volume textbook titled "Silicon Processing for the VLSI Era." Ex. 1008. A portion of the textbook focuses on CMOS technology. Ex. 1008A, 807–40.

3. *Analysis—Claim 1*

The preamble of independent claim 1 recites "A semiconductor device, comprising." Ex. 1001, 4:45. To the extent the preamble is limiting, Petitioner persuasively demonstrates that Wieczorek discloses a "semiconductor device 100." Pet. 47 (citing Ex. 1006 ¶ 12; Ex. 1003 ¶ 123).

Claim 1 also recites "a substrate of a first doping type at a first doping level having first and second surfaces." Ex. 1001, 4:46–47. Petitioner contends that Wieczorek in combination with Wolf discloses this limitation. In support, Petitioner provides an annotated version of Figure 1b of Wieczorek, which is reproduced below.

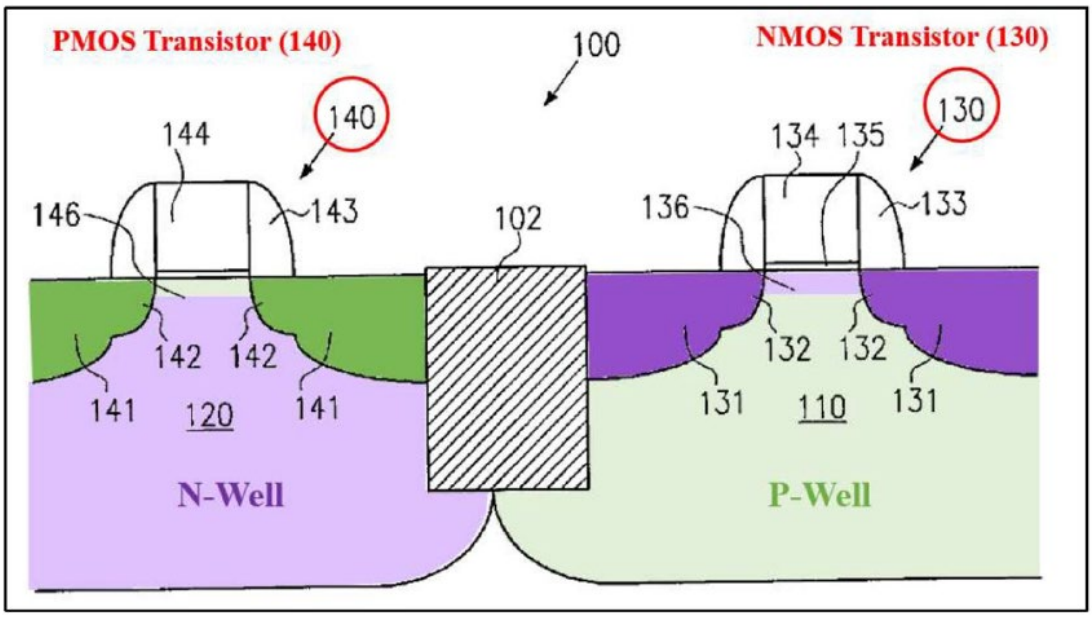


Figure 1b is annotated to show N-channel transistor 130 (nMOS) with source/drain regions 131 and 132 (purple) and channel region 136 (light purple) formed in P-well 110 (light green). Pet. 47–48. Figure 1b is also annotated to show P-channel transistor 140 (pMOS) with source/drain regions 141 and 142 (green) and channel region 146 (light green) formed in N-well 120 (light purple). *Id.*

Petitioner contends that Wieczorek explains that the P-well and N-well structures may be formed on any "appropriate substrate," but does not explicitly specify what that appropriate substrate may be. *Id.* at 47–48 (citing Ex. 1006 ¶ 4; Ex. 1003 ¶ 125). Petitioner asserts, however, that one of ordinary skill in the art would have understood that a twin well approach is "independent of the starting material type" for the substrate, and such an ordinarily skilled artisan would have consulted Wolf to confirm that a "***uniform***, lightly doped *p*- or *n*- type substrate" is a suitable substrate that is commonly used in twin-well CMOS devices.[16] *Id.* at 48 (citing Ex. 1008C, 523–24, 530; Ex. 1008B, 387–389; Ex. 1003 ¶ 126). According to Petitioner, one of ordinary skill in the art would have found it obvious to use a uniformly doped n- or p- type substrate as "[d]oing so would amount to combining known prior art elements . . . according to known methods . . . to obtain predictable results." *Id.* at 49 (citing Ex. 1003 ¶ 127). Petitioner identifies the top of the device as the claimed "first surface" and the bottom of the substrate as the claimed "second surface." *Id.* at 50 (citing Ex. 1003 ¶ 128).

Claim 1 also recites "a first active region disposed adjacent the first surface of the substrate with a second doping type opposite in conductivity

[16] Petitioner contends Wolf is "a well-known textbook," and relies on Wolf for teaching "known fundamental features and concepts related to semiconductor manufacturing, with particular emphasis on CMOS devices." Pet. 46 (citing Ex. 1008A, Chapter 16; Ex. 1003 ¶ 122). According to Petitioner, a person of ordinary skill in the art would have understood and expected that the teachings of Wolf would apply to Wieczorek's conventional CMOS device, and would have looked to Wolf for additional details related to conventional CMOS devices. *Id.* Patent Owner does not dispute this assertion.

to the first doping type and within which transistors can be formed." Ex. 1001, 4:48–51. Petitioner contends that Figure 1b of Wieczorek shows nMOS transistor 130 that includes "heavily N-doped ***source and drain regions*** 131, including lightly doped extensions 132" and "channel region 136." Pet. 51 (citing Ex. 1006 ¶¶ 4, 12–13). Petitioner further contends that nMOS transistor 130 is formed in the surface of the first active region, which is adjacent the surface of the substrate and, because the source-drain regions are N-doped, the first active region has a second doping type that is opposite in conductivity to the first doping type (P-type). *Id.* at 52–53.

Claim 1 also recites "a second active region separate from the first active region disposed adjacent to the first active region and within which transistors can be formed" and "transistors formed in at least one of the first active region or second active region." Ex. 1001, 4:52–56. Petitioner contends that P-channel transistor 140 of Wieczorek includes heavily P-doped source and drain regions 141, lightly doped extensions 142, and channel region 146, which are part of the claimed second active region. Pet. 54–55 (citing Ex. 1006 ¶¶ 4, 7, 12–13; Ex. 1003 ¶¶ 135–138; Ex. 1008B, 298–301, Figs. 5-1, 5-2, 6-4)). According to Petitioner, this second active region is disposed adjacent to the first active region and transistors (one or more), such as P-channel transistor 140, can be formed in the surface of this second active region. *Id*. Petitioner also contends that Wieczorek discloses forming multiple pMOS transistors in the second active region. *Id.* at 55–56 (citing Ex. 1006 ¶4; Ex. 1003 ¶ 137).

Claim 1 also recites "at least a portion of at least one of the first and second active regions having at least one graded dopant concentration to aid carrier movement from the first surface to the second surface of the substrate." Ex. 1001, 4:57–60. Petitioner contends that the doping

concentration of the substrate of Wieczorek is shown in Figure 2b (reproduced above), and shows a dopant concentration that is highest at the surface of the substrate and decreases with depth. Pet. 56–58 (citing Ex. 1006 ¶¶ 4, 9, 11–13, Figs. 2a-2b; Ex. 1008B, 298–301, Fig. 5-2; Ex. 1003 ¶ 141). Petitioner further contends that Wieczorek's downward-sloping graded dopant concentration aids carrier movement from the first surface to the second surface of the substrate. *Id.* at 59–60 (citing Ex. 1003 ¶¶ 144; Ex. 1010, 2:27–32, 5:13–22).

Patent Owner contends the "Petition's Wieczorek grounds fail for similar reasons as the Kawagoe grounds: Wieczorek does not say that the dopant gradient it discloses has any effect on carriers at all." PO Resp. 20 (citing Ex. 2057 ¶¶ 56–57). Patent Owner contends a downward sloping gradient concentration alone is not sufficient to establish the "aid carrier movement" claim limitation, and "Dr. Benerjee's declaration does not indicate that he calculated the slope of the graded concentration curve in Wieczorek." *Id.* at 21. "Indeed," according to Patent Owner, "it would have been impossible for him to make such a calculation, because the dopant gradient Petitioners point to in Figure 2B (and Wieczorek generally) does not have any values from which one could calculate a slope." *Id.* at 21–22.

Patent Owner's arguments are not persuasive. Petitioner persuasively demonstrates that Wieczorek discloses a graded dopant concentration that extends from the first surface to a second surface of the substrate and decreases with depth. Pet. 57 (citing Ex. 1006 ¶¶ 9, 11, 13, Figs. 1b, 2b). Dr. Banerjee persuasively testifies that the decreasing dopant concentration that extends from the first surface to the second surface of the substrate will create a static, unidirectional drift field that will "aid carrier movement." Ex. 1003 ¶¶ 141–144; Ex. 1060 ¶¶ 19–24. Patent Owner's counter-

arguments are not persuasive for the same reason discussed above with respect to Kawagoe.

In its Sur-reply, Patent Owner contends that Dr. Banerjee admitted during his deposition that a flat or non-graded dopant concentration would not create any electric field, and Patent Owner asserts that Wieczorek "does not have a graded dopant concentration in the active region (or surface) because the doping "profile in the *vicinity of the surface of the semiconductor device* 100, as indicated by reference number 200, may have become ***substantially uniformly distributed***." Sur-reply 22–23 (citing Ex. 2078, 209:5–9, 212:19–213:1, 260:6–13; Ex. 1006 ¶ 11).

In his first declaration, Dr. Banerjee acknowledged the disclosure referenced by Patent Owner, and testified that Wieczorek's "description is made relative to the 'initial retrograde profile' shown in Figure 2a" and is not inconsistent with his "understanding that Wieczorek still teaches and depicts a graded dopant concentration that is downward-sloping from the top surface of the substrate." Ex. 1003 ¶ 141.

Patent Owner did not address Dr. Banerjee's testimony or conclusions with respect to Figures 2a and 2b in its Response. Rather, Patent Owner chose to wait until its Sur-reply to address this evidence and Dr. Banerjee's conclusions. Regardless, Patent Owner fails to address Dr. Banerjee's specific testimony that Figure 2b of Wieczorek discloses the graded dopant profile *after annealing*. Ex. 1003 ¶ 141 (citing Ex. 1006 ¶¶ 9, 11, 13 ("[T]he initial dopant concentration, as shown in FIG. 2a, will be even more strongly affected so that, after the plurality of heat treatments, the actual dopant concentration will be represented by the graph shown in FIG. 2b.")). Thus, despite Wieczorek's statement that its dopants are "substantially uniformly distributed" after annealing, Figure 2b demonstrates that the graded dopant

profile of Wieczorek is not "flat," as asserted by Patent Owner. Ex. 1006 ¶ 13, Fig. 2b.

Upon review of the parties' arguments and supporting evidence, we determine that Petitioner persuasively identifies where Wieczorek and Wolf teach or suggest every limitation of challenged claim 1. Pet. 47–60. Petitioner also provides a persuasive, undisputed rationale as to why one of ordinary skill in the art would have sought to combine Wieczorek and Wolf. *Id.* at 45–46 (asserting that Wolf is a "well-known text book" and one of ordinary skill in the art would have "understood and expected that the teachings of Wolf would apply to Wieczorek's conventional CMOS device"). Thus, Petitioner persuasively demonstrates that claim 1 would have been obvious in view of Wieczorek and Wolf.

4. *Independent Claim 9 and Dependent Claims 2, 3, 5–8, 10, 11, and 13–18*

Petitioner contends the subject matter of independent claim 9 and dependent claims 2, 3, 5–8, 10, 11, and 13–18 would have been obvious in view of Wieczorek and Wolf. Pet. 61–69. In support of its arguments, Petitioner identifies where these references teach or suggest every limitation of these claims. *Id.*

Patent Owner does not address Petitioner's arguments with respect to these claims, apart from its arguments related to independent claim 1. *See e.g.*, PO Resp. 20–22.

Upon review of the parties' arguments and evidence, we determine that Petitioner persuasively identifies where every limitation of claims 2, 3, 5–11, and 13–18 is disclosed in Wieczorek and Wolf. Thus, Petitioner demonstrates by a preponderance of the evidence that these claims would have been obvious in view of Wieczorek and Wolf.

H. Reliance on Dr. Banerjee's Testimony

Patent Owner contends that Dr. Banerjee's testimony is "unreliable and should be disregarded for numerous reasons." PO Resp. 29. In particular, Patent Owner contends that Dr. Banerjee's declaration is unreliable because (1) he did not write and/or validate each statement or assertion made in his declaration; and (2) Dr. Banerjee has a monetary conflict of interest due to his pre-existing relationship with Texas Instruments ("TI"), which has joined IPRs addressing all asserted patents. PO Resp. 29–33; Sur-reply 12–14.

1. *Manner of Drafting the Declaration*

Patent Owner contends Dr. Banerjee admitted that he did not write his entire declaration and included material that was provided to him by Petitioner's attorneys, which he did not necessarily verify. PO Resp. 29–30. Patent Owner further asserts that Dr. Banerjee's declaration relies on the same grounds as those presented by Dr. Travis Blalock in another proceeding related to the '842 patent and his analysis "matches Dr. Blalock's declaration nearly verbatim." *Id.* at 30 (citing Ex. 1003; Ex. 2076). According to Patent Owner, "it is apparent that Petitioners just asked Dr. Banerjee to sign on to Dr. Blalock's existing analysis, and Dr. Banerjee complied." *Id.* at 31. Patent Owner also contends that Dr. Banerjee included a paragraph in his declaration stating that "[a]n internet search for [the Wolf textbook title]" "limited to the '.edu' domain yields over 800 results," but he did not do that search himself or confirm that it is accurate. *Id.*

Declarants have broad latitude in how they research, structure, and draft their declarations. They may rely upon information that they

personally identified or information provided by the parties' attorneys. They may also adopt nearly verbatim a previous declarant's testimony. Indeed, this procedure is often employed when a previous declarant is no longer able to testify in a proceeding. *See Jeisys Medical Inc v. Serendia, LLC*, IPR2024-00384, Paper 8 (PTAB March 1, 2024). This does not make the declaration inherently unreliable or necessarily entitled to less weight.

Through effective cross-examination, counsel may identify portions of a declaration that the declarant cannot explain or justify. In that case, the declarant's testimony on those matters may be entitled to less or even no weight, and if it happens repeatedly may lead to a conclusion that the entire declaration should be given little to no weight. Patent Owner identifies no testimony related to the key, disputed issues in this case, however, that Dr. Banerjee could not explain or provide the basis for his testimony. As such, we find that the manner in which Dr. Banerjee's declaration was drafted does not require that we disregard or give less weight to his testimony.

2. *Conflict of Interest*

Patent Owner contends that Dr. Banerjee depends on research funding from private industry for his career advancement and has only two active private grants, one of which is from TI[17] and provides $90,000 for his lab. Sur-reply 12 (citing Ex. 2078, 29:4–7, 29:14–30:4, 46:22–47:7). Dr. Banerjee also indicated that he plans to pursue additional funding from TI in the future. *Id.* at 13 (citing Ex. 2078, 49:15–50:1).

[17] TI is not a party to this proceeding.

Declarants are often well paid for their efforts. *See* Ex. 1003 ¶ 2 (Dr. Banerjee explaining that he is being compensated $675 per hour in this proceeding). This does not make their testimony inherently unreliable. Dr. Banerjee's financial interest with TI does have the potential to bias his testimony, but it does not make it inherently unreliable or inadmissible.

I. Timeliness of the Petition

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. 33. In particular, Patent Owner argues Petitioner is in privity with [redacted] 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 '842 patent. *Id.* at 43.

Prior to institution, Patent Owner's arguments regarding privity were based on several theories, including that "[b]y making custom licensed products for Licensees, Petitioners step into their shoes, and serve as their 'agent,' by exercising Licensees 'have made' rights under the license." Prelim. Resp. 3. Patent Owner also argued that Petitioner and the Licensees "are 'preceding and succeeding owners of' licensed (or infringing) products," that Petitioner is a beneficiary of the Licensees' agreements related to accused products, that Petitioner's licensed sales encumber otherwise infringing articles, and that Petitioners apparently indemnify the time-barred parties for custom-made products. *See* Prelim. Resp. 3, 22–30.

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 Techs., 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 factual basis upon which to question Petitioner's representation that it is not time barred (Inst. Dec. 24), or that Petitioner and Intel were privies, based on any of its theories regarding privity. *Id.* at 12–24. We incorporate that analysis here, and reconsider Patent Owner's contentions only to the extent it is warranted by subsequent argument and evidence. *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. 41–43); (2) Patent Owner had no opportunity to raise a res judicata defense in district court (*id*. at 48 n.8); (3) our finding that Petitioner's relationship with Intel [redacted][18] did not create privity misallocated the § 315(b) burden of proof by requiring

[18] Although we reference Patent Owner's arguments with respect to Intel, [redacted] and [redacted] as noted in the Institution Decision, Patent Owner presents no evidence that [redacted] and [redacted] are time-barred parties with respect to the '842 patent. Inst. Dec. 15–16 (noting the lack of any evidence that either [redacted] or [redacted] was served with a complaint alleging infringement of the '842 patent more than one year before the filing of the Petition); Prelim. Resp. 3–5. Thus, the ultimate focus must be on any potential relationship with Intel.

Patent Owner to produce evidence of Petitioner's and Intel [redacted] relationship (*id*. at 48); 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 generally presented these arguments in its request for Director review of our Institution Decision (Paper 33), which was summarily denied (Paper 35). Further, these arguments are not based on any evidence that was entered subsequent to our Institution Decision. Indeed, although Patent Owner unsuccessfully sought additional discovery relating to § 315(b) prior to our Institution Decision (Papers 10, 19), our Order denying that discovery noted that Patent Owner's discovery requests were "not narrowly tailored" to discover any indemnification agreement that relates to the prior infringement litigation against [redacted] Intel, [redacted] or to discover the relationship between Petitioners and [redacted] Intel, [redacted] as it relates to the prior infringement litigation, allegedly infringing products, or the IPRs (Paper 19, 12, 16). Patent Owner did not renew or re-tailor its request for additional discovery during trial or limit such requests to the specific products involved in previous litigations. *See Samsung Elects. Co. v. Netlist, Inc.*, IPR2022-00615, Paper 40 at 8 (PTAB Feb. 3, 2023) (Director Review Decision) (granting narrowly tailored discovery requests for any agreements between the relevant parties "related to the products accused of infringing" the involved patent, but denying as "speculative, unclear, and overly broad" a request for *all* supplier agreements between the parties); Paper 10, Appendix A (Patent Owner requesting all agreements and communications between any Petitioner and any Licensee). 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 alleged denial of an 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 that it had a standard customer-supplier relationship with Licensees. 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), and it must have an opportunity to show that the facts relied upon are untrue. *Id.* at 60.

Patent Owner's arguments are 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 more narrowly tailored discovery requests during trial through the regular course (as our rules provide), such as discovery of the scope the Director previously determined was appropriate in similar circumstances, we do not agree it has been denied due process. *See Samsung*, Paper 40 at 8–10.

Patent Owner's assertion that "the Board apparently relied on" Petitioner's assertion that it merely had "a standard supplier-customer relationship" is incorrect. The Institution Decision did not cite to or rely upon any representations from Petitioner or its counsel regarding the scope of the supplier-customer relationships between the various parties. Nor was our determination that a privity relationship had not been demonstrated based on examining the terms of Petitioner's customer relationships. *See* PO Resp. 60. As explained in our Institution Decision, a manufacturer-

customer relationship, by itself, does not necessarily suggest a privity relationship. Inst. Dec. 15–16. Thus, we did not need to, and did not, rely on the specific terms of the customer supplier relationships. *Id.* at 15–19 (noting that Patent Owner has directed us to no evidence tending to support the existence of an indemnification obligation creating a privity relationship).

In view of the foregoing, we are not persuaded that Patent Owner was denied an opportunity to examine evidence underlying our Institution Decision.

IV. MOTION TO EXCLUDE

Petitioner moves to exclude the declaration of Dr. Rao (Ex. 2072). Paper 63 ("Mot."). Dr. Rao's declaration contains six paragraphs, which are provided to support Patent Owner's arguments with respect to objective indicia of non-obviousness. Ex. 2072. In his declaration, Dr. Rao identifies specific licenses and how much licensing revenue Patent Owner has received from each party. Ex. 2072 ¶ 2. Dr. Rao also testifies that Patent Owner never threatened litigation against [redacted] or any of their affiliates, and received $30,000,000 from RPX for the license to [redacted] and [redacted] *Id.* ¶¶ 4, 6.

Petitioner contends Dr. Rao did not personally negotiate the licenses and learned of the facts from others and "was unaware of the amount each licensee contributed to the total payment under the first RPX license." Mot. 3. As Dr. Rao lacked personal knowledge of the facts alleged in the declaration, Petitioner contends the declaration should be excluded under Federal Rules of Evidence 402, 403, and 602.

We are not persuaded by this argument. Dr. Rao provides the identified licenses in the Appendix to his declaration and appears to have personal knowledge of much of his declaration testimony. For example, although he did not personally negotiate the licenses, he appears to have personal knowledge that they were entered into and how much licensing revenue was received. It is also sufficient for Dr. Rao to note that he is not aware of Greenthread ever threatening [redacted] or [redacted] with litigation, without having to rely upon potential hearsay testimony. As such, we decline to exclude his declaration.

We note, however, that Dr. Rao testifies that the RPX license provided rights to future patents Patent Owner may acquire, and he asserts that this "is a standard term in RPX licenses and many other licenses to ensure permanent peace between the parties." Ex. 2072 ¶ 3. As Dr. Rao does not adequately explain his basis for the testimony regarding the standard terms of RPX's licenses, we give this testimony little weight. Mot. 5.

In view of the foregoing, Petitioner's Motion to Exclude Exhibit 2072 is *denied*.

V. CONSTITUTIONALITY OF AIA

Patent Owner contends that we should dismiss the Petition "because the AIA violates the Supreme Court's non-delegation doctrine and the Constitution." PO Resp. 60. According to Patent Owner, once a threshold finding under § 314(a) is made, "the Director can institute or not institute for any reason, no reason, or a completely arbitrary reasons, like the flip of a coin." *Id.* at 62. And, absent an "intelligible principle for the Director to

apply," Patent Owner contends "the statute governing these proceedings is unconstitutional and the Petition must be denied." *Id.*

We decline to address Patent Owner's constitutional questions.

VI. CONCLUSION

For the foregoing reasons, we determine that Petitioner demonstrates by a preponderance of the evidence that claims 1–18 are unpatentable. Our conclusions are summarized in the following table.

Claim(s)	35 U.S.C. §	Reference(s)/Basis	Claim(s) Shown Unpatentable	Claim(s) Not Shown Unpatentable
1–18	103(a)	Kawagoe	1–18	
1–3, 5–11, 13–18	103(a)	Wieczorek, Wolf	1–3, 5–11, 13–18	
1–18	103(a)	Kawagoe, Gupta[19]		
1–3, 5–11, 13–18	103(a)	Wieczorek, Wolf, Gupta[20]		
Overall Outcome			1–18	

VII. ORDER

For the foregoing reasons, it is:

ORDERED that Petitioner demonstrates by a preponderance of the evidence that claims 1–18 of the '842 patent are unpatentable;

[19] Because we find that claims 1–18 would have been obvious over Kawagoe alone, we do not address whether these same claims would have been obvious over Kawagoe and Gupta.

[20] Because we find that claims 1–18 would have been obvious over Kawagoe, and that claims 1–3, 5–11, and 13–18 would have been obvious over Wieczorek and Wolf, we do not address whether these same claims would have been obvious over Wieczorek, Wolf, and Gupta.

ORDERED that Petitioner's Motion to Exclude Exhibit 2072 is *denied*;

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 the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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