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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SEMICONDUCTOR COMPONENTS INDUSTRIES, LLC and
TEXAS INSTRUMENTS INCORPORATED,
Petitioner,

v.

GREENTHREAD, LLC,
Patent Owner.

IPR2023-01243[1]
Patent 10,510,842 B2

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

HEANEY, *Administrative Patent Judge*.

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

[1] Texas Instruments Incorporated, which filed a petition in IPR2024-00672, has been joined as a petitioner in this proceeding.

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I. INTRODUCTION

A. Background

Semiconductor Components Industries, LLC ("Petitioner") filed a Petition (Paper 2, "Pet.") requesting *inter partes* review of claims 1–18 ("the challenged claims") of U.S. Patent No. 10,510,842 B2 (Ex. 1001, "the '842 patent"). Greenthread, LLC ("Patent Owner") filed a Preliminary Response (Paper 55, "Prelim. Resp.").[1] With Board authorization, Petitioner filed a Preliminary Reply (Paper 21), and Patent Owner filed a Preliminary Sur-reply (Paper 56). Upon consideration of these papers, we instituted *inter partes* review as to all challenged claims (Paper 31, "Inst. Dec.").

During the course of trial, Patent Owner filed a Patent Owner Response (Paper 58, "PO Resp."); Petitioner filed a Reply to the Patent Owner Response (Paper 69, "Pet. Reply"); and Patent Owner filed a Sur-reply (Paper 65, "PO Sur-reply"). Petitioner filed the Declaration of Travis Blalock, Ph.D. (Ex. 1003) in support of the Petition. Patent Owner filed the Declarations of Alexander Glew, Ph.D. (Ex. 2057) and Phil John (Ex. 2072) in support of its Response. The parties also filed transcripts of the depositions of Dr. Blalock (Ex. 2058), Dr. Glew (Ex. 1052), and Mr. John (Ex. 1053).

An oral hearing was held on November 13, 2024, and a transcript of the hearing is included in the record. Paper 81 ("Tr.").

[1] Unless noted otherwise, we cite to the public versions of the papers filed by the parties.

B. Related Proceedings

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

Greenthread, LLC v. Western Digital Corp., No. 1:23-cv-00326 (D. Del. filed March 24, 2023);

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 5, 1–2.

The parties also note that the '842 patent was at issue in a number of district court and *inter partes* review proceedings that are no longer pending. Pet. 2–3; Paper 5, 3–4.

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. *Id*. at 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.

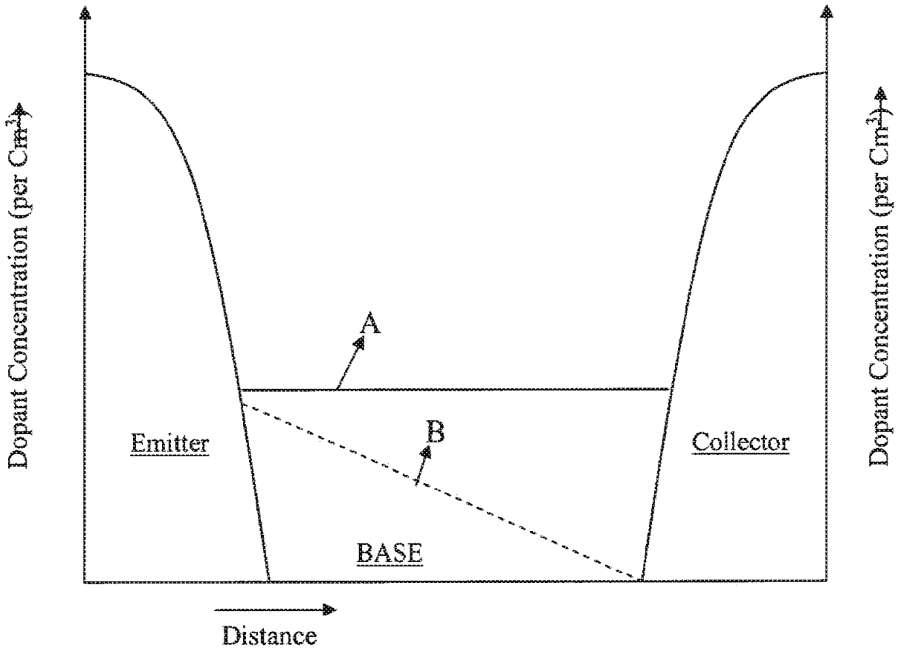

Figure 1 is labeled "Prior Art" and shows a plot of dopant concentration versus distance. Ex. 1001, Fig. 1. According to the '842 patent, Figure 1 "illustrates the relative doping profiles of emitter, base and collector for the two most popular bipolar junction transistors: namely, uniform base ('A')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

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

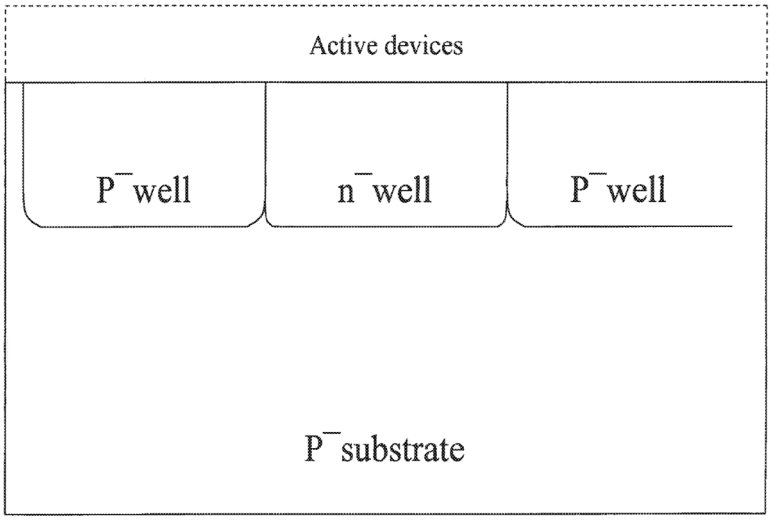

Figure 3A is labeled "Prior art (Twin well CMOS) for a CMOS integrated circuit" ("IC"), and shows a "typical" complementary metal-oxide-semiconductor ("CMOS") very large-scale integrated circuit ("VLSI") device that employs "a twin well substrate, on which active devices are subsequently fabricated." *Id*. at 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)").

Figure 5A of the '842 patent is reproduced below.

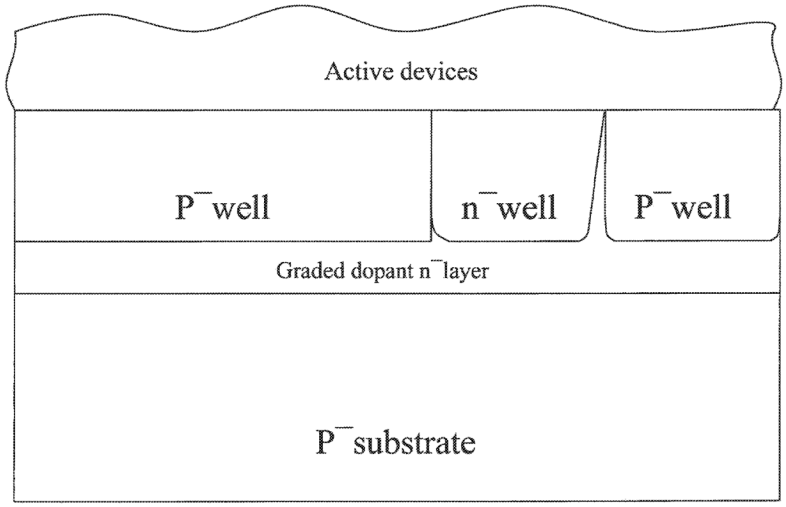

Figure 5A illustrates a cross section of a CMOS silicon substrate with two wells and an underlying layer using embodiments of the invention. *Id*. at 2:54–56. Figure 5A is labeled "[a] CMOS Substrate for digital, mixed[] signal, and sen[s]or[] IC's." Ex. 1001, Fig. 5A. The figure illustrates "a CMOS silicon substrate with two wells and an underlying layer," which is labeled "Graded dopant n^-layer." *Id*. at 2:54–58, Fig. 5A.

According to the '842 patent, "[s]purious minority carriers can be generated by clock switching in digital VSLI logic and memory ICs."

Ex. 1001, 3:47–48. The '842 patent states that these "unwanted carriers" degrade performance of various types of devices, including digital imaging ICs, and describes "a novel technique" 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 3:49–55, 3:60–64. For example, "[i]n a preferred embodiment, the subterranean n^- layer has a graded donor concentration to sweep the minority carriers deep into the substrate." *Id*. at 3:64–66.

D. Illustrative Claim

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

> 1. A semiconductor device, comprising:
>
> [1.1] a substrate of a first doping type at a first doping level having first and second surfaces;
>
> [1.2] 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;
>
> [1.3] a second active region separate from the first active region disposed adjacent to the first active region and within which transistors can be formed;
>
> [1.4] transistors formed in at least one of the first active region or second active region; and
>
> [1.5] 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 (bracketed numbering added by Petitioner).

E. Instituted Challenges to Patentability

We instituted review on the following challenges:

Claims Challenged	35 U.S.C. §[2]	Reference(s)/Basis
1, 2, 4–10, 12–18	103(a)	Kawagoe[3]
1, 2, 4–10, 12–18	103(a)	Kawagoe, Gupta[4]
1–3, 5–11, 13–18	103(a)	Wieczorek,[5] Wolf[6]
1–3, 5–11, 13–18	103(a)	Wieczorek, Wolf, Gupta

Pet. 5.

II. TIMELINESS OF PETITION UNDER 35 U.S.C. § 315(B)

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

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[2] The Leahy-Smith America Invents Act ("AIA"), Pub. L. No. 112-29, 125 Stat. 284, 287–88 (2011), included revisions to 35 U.S.C. §§ 102 and 103 that became effective in 2013, after the effective filing date of the challenged claims. *See* Ex. 1001, codes (22), (60). Therefore, we apply the pre-AIA versions of 35 U.S.C. §§ 102 and 103(a).

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

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

[5] US 2003/0183856 A1, published October 2, 2003 (Ex. 1006, "Wieczorek"). Petitioner asserts that Wieczorek is prior art under 35 U.S.C. §§ 102(a) and (e). Pet. 5.

[6] Stanley Wolf and Richard N. Tauber, *Silicon Processing for the VLSI Era*, Vols. 1–4, Lattice Press (2000) (Ex. 1008, "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. 5 (citing Exs. 1012, 1013, 1036). Exhibit 1008 was submitted in four parts (A–D) and includes selected portions of Wolf. We cite to Wolf using its original page numbers and omit the exhibit part designations.

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. 39. In particular, Patent Owner argues Petitioner is in privity with Intel Corp. ("Intel"), and [redacted] (collectively "Licensees"), who Patent Owner asserts are time-barred under 35 U.S.C. § 315(b) and licensed under the '842 patent. *Id.* at 41–47.

Prior to institution, Patent Owner's arguments regarding privity were based on several theories, including that Petitioner and Licensees "are 'preceding and succeeding owners of' the licensed and/or infringing products," that Petitioner is a beneficiary of the Licensee's agreements related to accused products, that Petitioner's licensed sales encumber otherwise infringing articles, that "Petitioners apparently indemnify the time-barred parties" for custom-made products, and that Petitioner serves as an "agent" of Licensees by exercising their "have made" rights under the license. Prelim. Resp. 1, 13–20.

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 Thryv, Inc. v. Click-to-Call Tech., LP,* 140 S.Ct. 1367, 1373 (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 conclude [redacted] is a time-barred entity (Dec. Inst. 12), or that Petitioner and Intel or [redacted] were privies, based on any of its theories regarding privity. *Id.* at 20. We incorporate that analysis here (*see* Dec. Inst. 10–20), and reconsider Patent Owner's contention only

to the extent it is warranted by subsequent argument and evidence.[7] *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. 44–45); (2) Patent Owner had no opportunity to raise a res judicata defense in district court (*id.* at 47–48); (3) our finding that Petitioner's relationship with Intel did not create privity misallocated the § 315(b) burden of proof by requiring Patent Owner to produce evidence of Petitioner's and Intel's relationship (*id.* at 48–49); and (4) a finding in Petitioner's favor would violate Patent Owner's constitutional right to due process. *Id.* at 61–62. We address these arguments below.

With regard to arguments (1)–(3), we note that Patent Owner presented these arguments in its request for Director review of our Institution Decision (Paper 36), which was summarily denied. Paper 43. 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 7, 31), our Order denying that discovery found that Patent Owner's discovery requests were not narrowly tailored to

[7] Patent Owner's exhibits 2001–2048 were entered prior to Institution. Patent Owner exhibits 2049–2082 were submitted during trial, with certain exceptions for redacted documents.

discover any indemnification agreement (Paper 30, 10), and Patent Owner did not renew or tailor its request for additional discovery during trial. In view of the denial of Director review and absence of additional evidence, we are not persuaded to reconsider Patent Owner's arguments (1)-(3).

Patent Owner's argument (4) regarding violation of its constitutional right to due process is based on denial of its opportunity to show that Petitioner's assertions as to its relationships with Licensees are untrue, and specifically, denial of its opportunity to cross-examine a witness about Petitioner's assertion that it did not indemnify Intel. PO Resp. 61–62 (citing *Goldberg v. Kelly,* 397 U.S. 254, 269 (1970); *Greene v. McElroy*, 360 U.S. 474, 496 (1959)). Patent Owner argues it had no notice of evidence to support a finding for Petitioner under § 315(b), asserting as an example, "the Board could only institute IPR if it found that Petitioner's customer-supplier relationships do not create privity by examining the terms of those relationships." *Id.* at 61.

Patent Owner's argument is not persuasive. As noted above, Patent Owner did not request additional discovery following entry of Petitioner's Preliminary Reply, or during trial. Because Patent Owner did not pursue discovery during trial through the regular course as our rules provide, we do not agree it has been denied due process. Further, we do not agree with Patent Owner's assertion that our determination that it did not demonstrate privity was necessarily based on examining the terms of Petitioner's customer relationships. *See* PO Resp. 61. As explained in our Institution Decision, a manufacturer-customer relationship does not necessarily suggest a privity relationship, and because Petitioner's sales to Intel are licensed (as Patent Owner acknowledges), they do not support privity. Dec. Inst. 13.

The record thus demonstrates that Patent Owner's argument that it was denied an opportunity to examine evidence underlying our Institution Decision lacks support.

III. PATENTABILITY ANALYSIS

A. Legal Standards

"In an [*inter partes* review], the petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable." *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir. 2016). The burden of persuasion never shifts to Patent Owner. *Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015).

A claim is unpatentable under 35 U.S.C. § 103 if "the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains." 35 U.S.C. § 103. The question of obviousness is resolved on the basis of underlying factual determinations including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) when present, objective evidence of nonobviousness. *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

To show obviousness, it is not enough to merely show that the prior art includes separate references covering each separate limitation in a challenged claim. *Unigene Labs., Inc. v. Apotex, Inc.*, 655 F.3d 1352, 1360 (Fed. Cir. 2011). "Rather, obviousness requires the additional showing that a person of ordinary skill at the time of the invention would have selected and

combined those prior art elements in the normal course of research and development to yield the claimed invention." *Id.* (citing *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 421 (2007)). "This is so because inventions in most, if not all, instances rely upon building blocks long since uncovered, and claimed discoveries almost of necessity will be combinations of what, in some sense, is already known." *KSR*, 550 U.S. at 418–19. On the other hand, an obviousness analysis "need not seek out precise teachings directed to the specific subject matter of the challenged claim, for a court can take account of the inferences and creative steps that a person of ordinary skill in the art would employ." *Id.* at 418; *accord In re Translogic Tech., Inc.*, 504 F.3d 1249, 1259 (Fed. Cir. 2007). Nevertheless, "[a] factfinder should be aware, of course, of the distortion caused by hindsight bias and must be cautious of arguments reliant upon *ex post* reasoning." *KSR*, 550 U.S. at 421.

Notwithstanding what the teachings of the prior art would have suggested to a person of ordinary skill in the art, objective evidence of non-obviousness may lead to a conclusion that the challenged claims would not have been obvious. *In re Piasecki*, 745 F.2d 1468, 1471–72 (Fed. Cir. 1984). Objective evidence of non-obviousness "may often be the most probative and cogent evidence in the record" and "may often establish that an invention appearing to have been obvious in light of the prior art was not." *Transocean Offshore Deepwater Drilling, Inc. v. Maersk Drilling USA, Inc.*, 699 F.3d 1340, 1349 (Fed. Cir. 2012) (quoting *Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 1538 (Fed. Cir. 1983)). Such evidence, however, does not necessarily control the obviousness conclusion. *See, e.g., Pfizer, Inc. v. Apotex, Inc.* 480 F.3d 1348, 1372 (Fed. Cir. 2007) ("Here, the

record establishes such a strong case of obviousness that Pfizer's alleged unexpectedly superior results are ultimately insufficient.").

B. Level of Ordinary Skill in the Art

Factors pertinent to determining the level of ordinary skill in the art include (1) the educational level of the inventor; (2) the type of problems encountered in the art; (3) prior-art solutions to those problems; (4) the rapidity with which innovations are made; (5) the sophistication of the technology; and (6) the educational level of workers active in the field. *Envtl. Designs, Ltd. v. Union Oil Co.*, 713 F.2d 693, 696–97 (Fed. Cir. 1983). Not all factors may exist in every case, and one or more of these or other factors may predominate in a particular case. *Id.* These factors are not exhaustive, but merely a guide to determining the level of ordinary skill in the art. *Daiichi Sankyo Co. v. Apotex, Inc.*, 501 F.3d 1254, 1256 (Fed. Cir. 2007).

Petitioner argues a person of ordinary skill in the art "would have had a Bachelor's degree in electrical engineering, material science, applied physics, or a related field, and four years of experience in semiconductor design and manufacturing or equivalent work experience." Pet. 8 (citing Ex. 1003 ¶ 49). According to Petitioner, "[a]dditional education might compensate for less experience, and vice-versa." *Id.*

Patent Owner argues

> [a] person of ordinary skill in the art (POSITA) in the technology field of the Challenged Patent would be a person with at least a Bachelor's of Science degree in electrical or computer engineering, materials science, chemical engineering, applied physics, or a related field, with emphasis on semiconductor manufacturing, or an equivalent degree, and at least four years of experience in semiconductor design and manufacturing.

> Additional education in a relevant field or industry experience may compensate for a deficit in one of the other aspects of the requirements stated above.

PO Resp. 12 (citing Ex. 2057 ¶¶ 17–18).

Petitioner and Patent Owner's definitions for the ordinary level of skill in the art are substantially similar. In light of the record before us, we adopt Petitioner's proposal regarding the level of ordinary skill in the art. Based on our review of the '842 patent and the prior art of record, we determine that Petitioner's definition comports with the qualifications a person would have needed to understand and implement the teachings of the '842 patent and the prior art. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001) (explaining that specific findings regarding ordinary skill level are not required "where the prior art itself reflects an appropriate level and a need for testimony is not shown") (quoting *Litton Indus. Prods., Inc. v. Solid State Sys. Corp.*, 755 F.2d 158, 163 (Fed. Cir. 1985)). The outcome of our Decision does not depend on which party's definition is selected. Patent Owner does not argue the result would change if its definition were adopted.

C. Claim Construction

We construe claim terms "using the same claim construction standard" that district courts use to construe claim terms in civil actions under 35 U.S.C. § 282(b). *See* 37 C.F.R. § 42.100(b) (2023). Under that standard, claim terms "are given their ordinary and customary meaning, which is the meaning the term would have to a person of ordinary skill in the art at the time of the invention." *Power Integrations, Inc. v. Fairchild Semiconductor Int'l, Inc.*, 904 F.3d 965, 971 (Fed. Cir. 2018) (citing *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–13 (Fed. Cir. 2005) (en banc)). The meaning of claim terms may be determined by "look[ing] principally to the

intrinsic evidence of record, examining the claim language itself, the written description, and the prosecution history, if in evidence." *DePuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.*, 469 F.3d 1005, 1014 (Fed. Cir. 2006) (citing *Phillips*, 415 F.3d at 1312–17).

Neither party proposes any claim term for express construction. Pet. 9; PO Resp. 13 (citing Ex. 2057 ¶¶ 20–25, 45). Patent Owner, however, implicitly construes "at least one graded dopant concentration to aid carrier movement" to require carrier movement, and Petitioner disagrees. We address the implicit construction in section III.E.2. below.

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

D. Objective Indicia of Nonobviousness[8]

Patent Owner alleges that a license agreement with RPX Corp. ("RPX") ("the RPX license") that covers the patent family including the '842 patent is evidence supporting the objective indicia of nonobviousness. PO Resp. 2, 35–37. Patent Owner further argues that because the licensees, [redacted] approached Patent Owner through RPX without threat of litigation against them, the RPX license agreement is

[8] In Section III.D, we refer to the sealed version of the Patent Owner Response (Paper 46).

especially probative of non-obviousness. *Id.* at 35–36 (citing Ex. 2072). Patent Owner further argues that its invention is "part and parcel" of the RPX license because all of the claims of the licensed patents relate to using graded dopants to move carriers from active circuitry at the surface further down into the device. *Id.* at 37.

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

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

Here, Patent Owner does not expressly address the nexus requirement, but it relies on the RPX license and asserts that its technique of "creating 'a drift field to sweep these unwanted minority carriers from the active circuitry at the surface into the substrate'" (PO Resp. 37, quoting Ex. 1001, 3:52–56) is "part and parcel" with the RPX license. *Id.* at 37. We have considered the RPX license and Patent Owner's argument, and find that they do not demonstrate a sufficient nexus with the challenged claims. In particular, the RPX license on its face does not refer to the claimed feature of using a graded dopant that PO asserts as "part and parcel" of all of the licensed patents, nor does it refer to any technical merits of the challenged claims. Further, Patent Owner offers no evidence that any licensee mentioned the challenged '842 patent or the claimed feature of using a graded dopant during negotiation of the RPX license, and no information relating to [redacted] consideration of the potential exposure of their products. Without this information, it is difficult to assess whether [redacted] through the RPX license, acquiesced to the purported strength of the '842 patent. We find that the mere existence of the RPX license is not sufficient to show a nexus.

Even if Patent Owner were found to have shown a nexus, we decline to give significant weight to the RPX license because there is insufficient evidence to evaluate its context. Further, we do not agree with Patent Owner that the RPX license is "especially probative" because [redacted] were under no apparent threat of litigation. *See* PO Resp. 36. Although Patent Owner argues that the RPX license was not motivated by a threat of litigation, and that the expense for [redacted] to litigate the challenged patents "would have been trivial" (*see id.*), the weight of

evidence does not support those arguments. RPX markets itself as a cost-saving service that spreads litigation cost across a large network of companies and "remove[s] patents from circulation before they become costly issues." Ex. 1051, 1. RPX further markets itself as working on behalf of its clients to prevent potential litigation and associated legal defense costs and settlements. *Id.* at 3. In view of this evidence, Patent Owner's argument that [redacted] entered a license under no apparent threat of litigation is not persuasive.

As to Patent Owner's argument that the licenses evidence non-obviousness because "moving carriers 'from the active circuitry at the surface' is missing from the prior art" (PO Resp. 37), we disagree that claim limitation [1.5 / 9.5] is missing from the prior art for the reasons discussed below in Section III.E.2. *See Tokai Corp. v. Easton Enters., Inc*., 632 F.3d 1358, 1369 (Fed. Cir. 2011) ("If commercial success is due to an element in the prior art, no nexus exists."); *Ormco Corp. v. Align Technology, Inc*., 463 F.3d 1299, 1312 (Fed. Cir. 2006) ("[I]f the feature that creates the commercial success was known in the prior art, the success is not pertinent.").

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

E. Obviousness over Kawagoe

Petitioner challenges claims 1, 2, 4–10, and 12–18 as obvious based on Kawagoe. Pet. 5, 13–40. Patent Owner disagrees. *See generally* PO

Resp. For the reasons discussed below, Petitioner has established by a preponderance of evidence that claims 1, 2, 4–10, and 12–18 are obvious over Kawagoe.

1. Kawagoe (Ex. 1007)

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

[9] Petitioner submits Exhibit 1009 (Wang, Single Event Upset: An Embedded Tutorial, 21st Int'l Conf on VLSI Design, 429–434, IEEE 2008) ("Wang"), 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. Blalock characterizes "latchup" as "a 'short-circuit' failure condition in poorly designed circuits." Ex. 1003 ¶ 77.

to improve the resistance to the latchup." *Id*. at 4:1–8. Kawagoe discloses a process for manufacturing a semiconductor integrated circuit device including a step of forming a semiconductor region (well) extending below the epitaxial layer and having an impurity concentration that decreases with increasing depth below the epitaxial layer. *Id*. at 3:10–25. According to Kawagoe, the well can be used for forming a complementary Metal-Oxide-Semiconductor. Field-Effect-Transistor ("MOS.FET") circuit. *Id*. at 3:32–38.

Kawagoe describes seven embodiments, including Embodiment 1 (Ex. 1007, 6:41–12:40, Figs. 1–8) and Embodiment 4 (id. at 14:46–19:63, Figs. 16–25). Figure 1, reproduced below, depicts the device of Embodiment 1.

FIG. 1

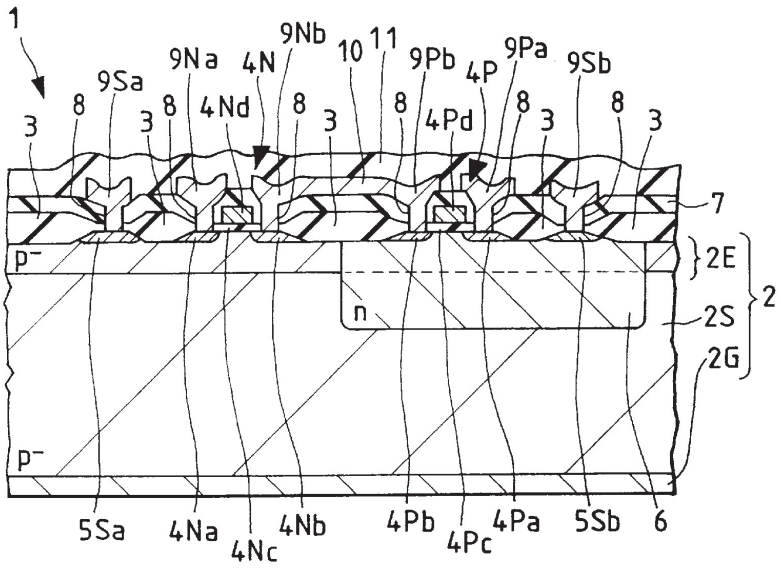


Figure 1 depicts "an essential portion of a semiconductor integrated circuit device" that includes semiconductor substrate body 2S, epitaxial layer 2E, and gettering layer 2G. *Id*. at 6:42–49, 6:51–56, Fig. 1. Substrate body 2S and epitaxial layer 2E are doped with a p-type impurity in equal

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. *Id.* at 17:11–13.

FIG. 23

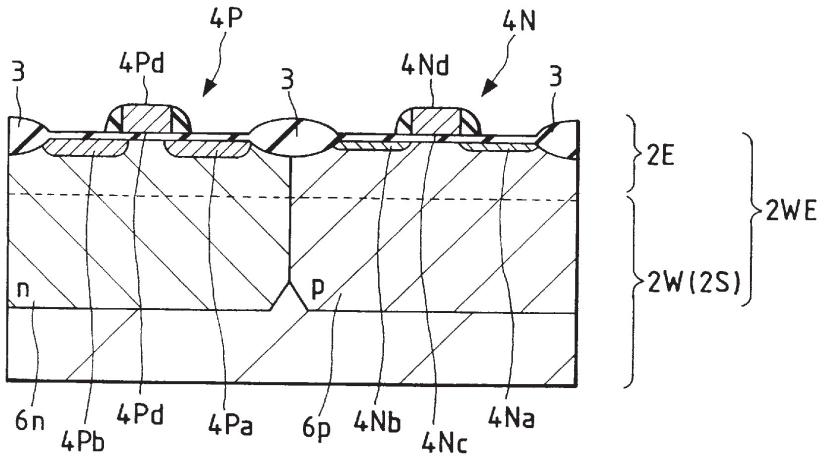


Figure 23 shows a step in a process for manufacturing the semiconductor integrated circuit device of Embodiment 4, including p-well 6p formed with nMOS 4N and n-well 6*n* formed with pMOS 4P. *Id*. at 6:1–4, 15:26–32, 18:3–35. Substrate body 2S and epitaxial layer 2E are doped with p-type impurity, and the impurity concentration of substrate body 2S is higher than that of epitaxial layer 2E "to improve the resistance to the latchup." *Id.* at 14:64–15:6, 15:13–17, 16:16–21, 19:59–63, Fig. 17. In Embodiment 4, the impurity concentration in p-well 6*p* and n-well 6*n* decreases with increasing depth below the epitaxial layer. *Id*. at 15:62–16:15, 17:55–61, Fig. 17. Kawagoe discloses that the concentration gradient reduces soft errors by

attracting carriers (electrons) to the substrate and preventing them from entering the p-well. *Id*. at 16:2–11.

Petitioner relies on Kawagoe Figure 17, which is reproduced below and illustrates properties of the semiconductor device of Embodiment 4.

FIG. 17

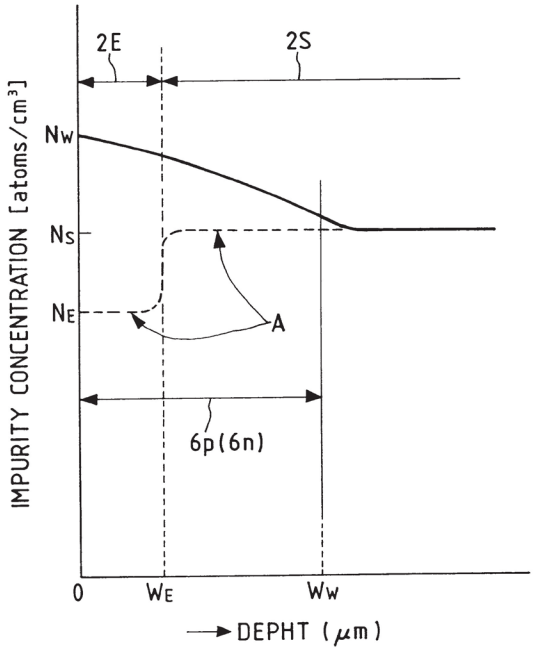


Figure 17 is a plot of impurity concentration as a function of depth in a semiconductor integrated circuit device, which shows "the p-well 6*p* and n-well 6*n* have their impurity concentrations gradually lowered in the depthwise direction from the principal surface (having an impurity concentration NW) of the epitaxial layer 2E." Ex. 1007, 5:41–45, 15:62–16:40.

2. Claim 1

a. [pre] "a semiconductor device"

Petitioner contends Kawagoe discloses a semiconductor device as recited in each limitation of claim 1. Pet. 13–14 (citing Ex. 1007, 1:13–23,

14:46–67, Figs. 16, 17, 23; Ex. 1003 ¶ 66). Generally, a preamble does not limit a claim. *Allen Eng'g Corp. v. Bartell Indus., Inc.*, 299 F.3d 1336, 1346 (Fed. Cir. 2002). We need not decide whether claim 1's preamble limits the claim because we agree with Petitioner that Kawagoe teaches claim 1's preamble.

b. [1.1] "a substrate of a first doping type at a first doping level having a surface."

Petitioner relies on Kawagoe's Embodiment 4, depicted in Figure 23, as disclosing limitation [1.1]. Pet. 14–15. Petitioner contends Kawagoe discloses "a substrate of a first doping type" because epitaxial layer 2E and substrate body 2S are doped with p-type impurity, and Kawagoe's epitaxial substrate has a top surface. *Id.* (citing Ex. 1007, 6:50–7:3, 14:61–15:12, 17:10–18:38, Figs. 20, 23).

Petitioner contends Kawagoe discloses "a first doping level" because Embodiment 1 has a uniformly-doped epitaxial substrate, with epitaxial layer 2E and substrate body 2S having the same impurity concentration. Pet. 16 (citing Ex. 1007, code (57), 2:57–3:9, 6:60–7:3). Petitioner contends a person of ordinary skill in the art would have understood that Kawagoe teaches forming a twin-well CMOS device on either a uniformly-doped epitaxial substrate, as described in Embodiment 1, or a non-uniformly doped latchup-resistant epitaxial substrate, as described in Embodiment 4. *Id.* at 16–17 (citing Ex. 1003 ¶ 72). Relying on Dr. Blalock's testimony and prior art disclosures cited in Kawagoe, Petitioner contends that a person of ordinary skill would have been motivated to use a uniformly-doped epitaxial substrate to form a twin-well CMOS device and would have had a reasonable expectation of success. *Id.* at 16–19 (citing Ex. 1003 ¶¶ 72–78;

Ex. 1007, 1:33–40, 2:57–65, 8:40–52, 12:8–40, 14:58–60, 15:7–40, 19:49–63, Fig. 23; Ex. 1008, 381, 387–89, 406, 419, 523, 530; Ex. 1026, 1).

Patent Owner does not dispute Petitioner's showing as to limitation [1.1]. Based upon Petitioner's undisputed showing as discussed above, we find that Kawagoe discloses limitations [1.3].

c. *[1.2] "a first active region disposed adjacent the surface with a second doping type opposite in conductivity to the first doping type and within which transistors can be formed"*

Petitioner contends Kawagoe discloses "semiconductor regions 4Na and 4Nb . . . for forming the source-drain regions of the nMOS 4N." Pet. 20 (citing Ex. 1007, 8:66–67, Fig. 23) (emphasis omitted). Petitioner contends Kawagoe's semiconductor regions 4Na and 4Nb (corresponding to the "first active region") have a doping type (n-type) opposite to the doping type (p-type) of the substrate. Pet. 20–21 (citing Ex. 1007, 8:67–9:3). Petitioner contends a person of ordinary skill in the art would have considered Kawagoe's source-drain regions 4Na and 4Nb, as well as the channel region between those regions and below insulating film 4Nc, as part of an active region. Pet. 21 (citing Ex. 1003 ¶ 80; Ex. 1014, 1:52–54, 2:17–21; Ex. 1020, 31).

Notwithstanding Patent Owner's arguments to the contrary, which we discuss below, we find that Petitioner demonstrates that Kawagoe teaches limitation [1.2].

Patent Owner contends the Petition fails to establish Kawagoe discloses limitation [1.2]. According to Patent Owner, "the Petition mapped 'a first doping type' to p-type doping" and "Kawagoe's [source-drain] regions 4Na and 4Nb 'have a second doping type (n-type) opposite in conductivity to the first doping type (p-type) of the substrate.'" PO Resp. 32

(citing Pet. 14, 20–21, 36). Patent Owner argues that "the Petition also states that the *channel* of transistor 4N is [*also*] part of the first active region." *Id.* (citing Ex. 1007, 8:66–9:3; Pet. 20 ("Source-drain regions 4Na/4Nb (purple) form part of the claimed first active region, which also includes the channel region")) (alteration added). Patent Owner thus contends, with respect to limitation [1.5] which recites "at least a portion of at least one of the first and second active regions having at least one graded dopant concentration"

> the Petition pointed to the concentration profile under the *channel*. But the channel of transistor 4N is doped *p-type*, because it is the top portion of a p-well (as shown in Figure 23 of Kawagoe).

Id. at 32 (citing-in-part Pet. 20 (Ex. 1007, Fig. 23, which shows channel of transistor 4N at the top of p-well 6p), *id.* ("the channel region (light purple) between source-drain regions 4Na/4Nb"), 18–20).

Patent Owner points to Dr. Glew's testimony and contends it "explain[s] that the channel in a CMOS transistor has the same doping type as the well in which the source and drain are formed)" and that "the channel of NMOS 4N made from *the p-well, the p-well, and the p-type substrate are all doped p-type*." *Id.* at 33 (citing Ex. 2057 ¶ 60) (emphasis added); *see* PO Sur-reply 11–14.

Having considered the evidence and arguments of both parties, we conclude that Petitioner persuasively demonstrates that a person of ordinary skill would have understood that the source-drain regions and channel regions are part of the active regions where transistor activity occurs. Pet. 20 (citing Ex. 1003 ¶ 79; Ex. 1008B, 299–300); PO Resp. 32 (citing Ex. 1007, 8:66–9:3; Pet. 14). The parties' dispute whether an active region

should be characterized by the dopant type of the source-drain regions, or by the dopant type of the channel region between the source and drain. We agree with Petitioner that there is insufficient support for interpreting the "'first active region' as *only* having the 'doping type' of the transistor channel." Pet. Reply 16 (citing PO Resp. 32–33) (emphasis added). Wolf supports Petitioner's position; it describes how a person of ordinary skill would have understood an *nMOS* as including a source and drain that are doped with an n-type dopant and "[a] *channel* region in the semiconductor under the gate electrode[,] separat[ing] the source and drain" that "is lightly doped with a dopant type *opposite* to that of the source and drain." Ex. 1008B, Fig. 5-1(a), 298 (emphasis added). Therefore, we agree with Petitioner that "the 'doping type' of the 'first active region'" may be "the doping type of the associated source and drain regions." *See* Pet. Reply 18; Sur-reply 12.

Patent Owner's argument that Kawagoe's channel region is not opposite in type to Kawagoe's epitaxial substrate—that is, epitaxial layer 2E and substrate body 2S doped with p-type impurity—is not persuasive because claim 1 is not so limited. *See* PO Sur-reply 11–14. Claim 1 requires a "first *active region* . . . with a second doping type opposite in conductivity to the first doping type," and does not specifically require *a channel region* with a doping type opposite in conductivity to the first doping type. As Petitioner has persuasively shown, a person of ordinary skill would have understood that the claimed "active region" of a MOS device may be characterized by the type of the source and drain of the MOS.

Dr. Glew testified that "[t]he claimed invention is clearly disclosed in Figs. 5B-5C of the Challenged Patent, and the corresponding parts of the

specification." Ex. 2057 ¶ 34. Like Kawagoe and Wolf, Figure 5B of the '842 patent depicts n-type source and drain regions, a p^- substrate, and a graded dopant region which "creates a drift field to sweep [] unwanted minority carriers from the active circuitry at the surface into the substrate in a monolithic die as quickly as possible." Ex. 1001, 3:61–64. The '842 patent further discloses that this graded dopant region can be implemented in a deeply-implanted n-layer, an epitaxial layer, an n-well, or a p-well, like Kawagoe, and when implemented in a well region, can be "graded or retrograded." *Id.* at 4:1–5. Accordingly, the '842 patent does not redefine, let alone differ from, Wolf concerning the naming convention for a CMOS comprised of NMOS and PMOS components.

Patent Owner argues in its Sur-reply that Petitioner's argument that the doping type of the source and drain doping may represent the doping type of the "active region" was improperly raised for the first time in its Reply. PO Sur-reply 12. We disagree. Petitioner has consistently argued that the source and drain are part of the first active region. Pet. 20. Petitioner also provides express support for this understanding from Wolf. *Id.* (citing Ex. 1008B, 299–300 ("The active regions are those in which transistor action occurs, i.e., the channel and the heavily doped source and drain regions.")).

Patent Owner also argues in its Sur-reply that the source and drain regions cannot be part of the "active region" because an "active region" can exist without a source and drain, with the claim indicating that the transistors are formed in the active region. PO Sur-reply 13 (citing Ex. 1052, 24:22–25, 27:25–28:2). This argument, in addition to being raised for the first time in Sur-reply, is in direct conflict with both Dr. Glew's declaration testimony

and the disclosures of Wolf. For example, as noted above, Wolf expressly states that "active regions" are those where transistor action occurs, and include both the channel and the source and drain regions. Ex. 1008B, 299–300. Consistent with this understanding, Dr. Glew testified that the "source and drain" of Kawagoe "are part of the active region." Ex. 1052, 137:6–14.

In view of the foregoing, we find that Kawagoe discloses limitation [1.2].

d. [1.3] "a second active region separate from the first active region disposed adjacent to the first active region and within which transistors can be formed"

[1.4] "transistors formed in at least one of the first active region or second active region; and"

Petitioner contends Kawagoe discloses limitations [1.3] and [1.4]. Patent Owner does not dispute this. *See generally* PO Resp. As we discuss below, Petitioner provides a detailed analysis showing where it contends Kawagoe discloses each of these limitations.

As to limitation [1.3], Petitioner contends Kawagoe discloses "semiconductor regions 4Pa and 4Pb . . . for forming the source-drain regions of the pMOS 4P." Pet. 23–24. Petitioner contends a person of ordinary skill in the art would have understood that source-drain regions 4Pa and 4Pb, as well as the channel region between those regions and below insulating film 4Pc, were part of an active region. *See id.* at 23; Ex. 1008B, 299–300 ("The active regions are those in which transistor action occurs; i.e., the channel and the heavily doped source and drain regions.").) Petitioner contends Kawagoe discloses this active region adjacent to the first active region and separated by an isolation region, i.e., insulating film 3. *Id.* (citing Ex. 1007, 14:46–55. Fig. 23; Ex. 1008A, 818–20, Fig. 16-11(f); Ex. 1003 ¶¶ 83–84).

As to limitation [1.4], by reference to the two preceding sections of the Petition (*see* Pet. 25), Petitioner contends Kawagoe discloses forming transistors 4N and 4P, each in an active region. *See* Pet. 20, 23 (citing Ex. 1007, 8:66–9:3, 9:47–50, Fig. 23). Petitioner contends Kawagoe's disclosures satisfy claim 1's recitation of "transistors" either under Patent Owner's district court construction of "transistors" as requiring one or more transistors, or under an alternative construction requiring multiple transistors in each active region. Pet. 21 ("a POSITA would have understood that Kawagoe teaches forming multiple nMOS transistors in this [first active] region to minimize chip area, as good layout practice dictates"), 24 ("a POSITA would have understood that Kawagoe teaches forming multiple pMOS transistors in this [second active] region").

Based upon Petitioner's undisputed showings, we find that Kawagoe discloses limitations [1.3] and [1.4].

> *e. [1.5] "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."*

Notwithstanding Patent Owner's arguments to the contrary, which we discuss below, Petitioner demonstrates how Kawagoe teaches a "graded dopant concentration to aid carrier movement from the first surface to the second surface of the substrate," as recited in limitation [1.5]. Pet. 25–27.

(1) The Parties' Contentions

Petitioner contends Kawagoe's Figure 17 illustrates a doping concentration that is "gradually lowered in the depthwise direction ***from the principal surface*** (having an impurity concentration NW) of the epitaxial layer 2E." Pet. 26 (quoting Ex. 1007, 15:62–16:40). Petitioner further

contends Kawagoe's dopant concentration is graded in the channel region of transistor 4N, which is a portion of the first active region formed at the top surface of epitaxial layer 2E. *Id.* (citing Ex. 1003 ¶ 89). Petitioner contends Kawagoe's Figure 17 shows a downward-sloping graded concentration from the top surface of the substrate, through the depth of the channel region and underlying well, for both transistor 4N and transistor 4P, and thus discloses "at least a portion of" the first and second active regions have a downward-sloping graded dopant concentration. *Id.* at 26–27 (citing Ex. 1007, 15:32–36, 15:62–16:2, Fig. 23; Ex. 1008B, 298–301, Figs. 5-2, 6-4).

Petitioner further contends the downward-sloping graded dopant concentration in Kawagoe Figure 17 aids the movement of carriers from the top surface of the epitaxial layer (corresponding to the "first surface" in limitation [1.5]) to the bottom surface of the substrate (corresponding to the "second surface" in limitation [1.5]), because Kawagoe discloses "the ***electrons produced by the a-ray are attracted to the substrate body 2S by that concentration gradient***." *Id.* at 28 (quoting Ex. 1007, 16:2–11, Ex. 1003 ¶ 92). Petitioner further contends Kawagoe discloses a downward-sloping graded dopant concentration that aids carrier movement from the first surface to the second surface of the substrate "to the same extent to which Applicant relied on the prior art and admitted to the Patent Office that such carrier movement would occur under the same scenario." *Id.* at 30 (citing Ex. 1003 ¶ 94). As support for that contention, Petitioner relies on the file history for the parent '195 patent[10] and references cited during examination. *Id.* at 30–32 (citing Exs. 1010, 1016, 1031).

[10] U.S. Patent No. 8,421,195 ("the parent '195 patent").

Patent Owner disputes Petitioner's showing as to Kawagoe based on five contentions: (1) a mere downward sloping gradient does not necessarily "aid carrier movement" and "Dr. Blalock admitted that, to determine whether a dopant concentration gradient would 'aid carrier movement,' he looked *only* at the direction of the slope" and "did not look at the magnitude of the slope or other possible forces acting on a carrier" (PO Resp. 16, 20–21); (2) Kawagoe "teach[es] that the graded concentration actually *inhibits* carrier movement" and Kawagoe's carriers are not in the active region and "nowhere near what Petitioner identifies as the 'surface'" (*id.* at 23–25); (3) the Petition improperly relies on Wang, a post-priority date reference, "to fill the gap" with respect to Kawagoe (*id.* at 25–26); (4) a person of ordinary skill in the art would have understood that Kawagoe's electrons that are prevented from entering the p-well are not created near the surface (*id.* at 27–28); and (5) all of Kawagoe's teaching about a gradient refers to gradients and carriers outside the active region. PO Sur-reply 9 (citing Pet. 28, n.9; PO Resp. 24).

(2) Analysis of Limitation [1.5]

Before turning to discussion of each of Patent Owner's contentions, we first address the parties' contentions with regard to Patent Owner's statements during prosecution, and interpretation of "to aid carrier movement" as recited in limitation [1.5].

During prosecution of the parent '195 patent, the Examiner rejected claims under the pre-AIA version of 35 U.S.C. § 112, first paragraph, arguing that "movement of minority carriers is affected by multiple forces and fields" and that "it does not appear that simply the presence of 'a unidirectional drift field' in itself can achieve 'drawing *all* minority carriers

from said surface layer to said substrate.'" Ex. 1016, 270 (emphasis added).

Patent Owner responded with following argument:

> [A] unidirectional drift (electric) field necessarily affects all the present minority carriers in the same way - moving all minority carriers in the same direction because of the unidirectional drift due to the existence of the electric field. *See* "Physics and Technology of Semiconductor Devices," A.S. Grove, pp. 224–225, John Wiley and Sons, Inc., New York, 1st Edition 1967 ("This same electric field will then be of such direction as to aid the motion of injected holes. Thus the injected minority carriers will now move not only by diffusion but also by drift due to the existence of this electric field."). Depending on the particular slope of the graded concentration of dopant, all minority carriers are either swept "down" (from the surface layer to the substrate) or "up" (from the substrate to the surface layer). *See* Applicant's Figs. 5(b) and 5(c).

Id. Patent Owner further argued that the Examiner's finding

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

Id. at 289–90 (emphases added). Also, "without conceding [its] position on this issue," Patent Owner amended the claims to no longer require "drawing all minority carriers," and instead, requiring that the claimed "unidirectional

drift field" created by the "graded concentration of dopants" "aid the movement of minority carriers." [11] *Id.* at 290.

Here, Patent Owner contends its statement was in response to an Office Action on a claim that required a "single static unidirectional electric drift field to aid the movement of carriers" (PO Resp. 15 (citing Ex. 1016, 286)), and those additional limitations were an additional parameter besides the graded dopants to "ensur[e] that all minority carriers are moved." *Id.* at 16. Patent Owner also points to the Examiner's statement during prosecution that in "a complex electronic device, movement of minority carriers is affected by multiple forces and fields" but "without knowing other parameters of the device" one cannot say whether a drift field would aid carrier movement. *Id.* (quoting Ex. 1016, 270). Thus, Patent Owner argues a mere downward sloping gradient, without additional calculation of slope, does not satisfy limitation [1.5]'s purported requirement to "aid carrier movement."

Petitioner argues the prosecution history above supports its contention that limitation [1.5] does not require that all minority carriers are moved. Pet. Reply 5 (citing Ex. 1016, 250, 269–270, 289–290). In other words, "the Examiner's focus on 'all' confirms that while additional parameters may be required for moving 'all' carriers, a graded dopant concentration resulting in a unidirectional drift field … is sufficient to move 'some' carriers," which is

[11] The examined claims of the '195 patent application generally recited "a unidirectional drift field drawing all minority carriers from said surface layer to said substrate." Ex. 1016, 286. Patent Owner amended the claims of the '195 patent application to recite "maintain[ing] a single static unidirectional electric drift field to aid the movement of minority carriers from said surface layer to said substrate." *Id*.

enough to satisfy limitation [1.5]. Pet. Reply 6–7 (citing Ex. 1016, 270; PO Resp. 16).

Petitioner also relies on Patent Owner's statement during prosecution of descendent U.S. Patent Application No. 17/728,588 ("the '588 application"), which claims priority to both the '842 and the '195 patents. During prosecution of the '588 application, Patent Owner asserted that "relative slope 'means nothing more than the fact that one side is relatively lower than the other.'" Pet. Reply 6 (citing Ex. 1054, 12; Ex. 1055, 5); Tr. 24:19–24.

Having considered the parties' arguments and evidence from the prosecution history, we determine that Patent Owner's statements during prosecution of the '195 parent patent were clear, unambiguous, and indicate that one of ordinary skill in the art need not know whether there are other "forces and field" in an electronic device, as the mere presence of a graded dopant concentration creating a "unidirectional drift field," facing in the appropriate direction, will "aid the movement of minority carriers from" the surface layer to the substrate. Ex. 1016, 270, 289–290. The public was entitled to rely on these clear and unambiguous statements when considering the scope of the challenged claims. *Hockerson-Halberstadt v. Avia Group Int'l*, 222 F.3d 951, 957 (Fed. Cir. 2000) ("The prosecution history constitutes a public record of the patentee's representation regarding the scope and meaning of the claims, and competitors are entitled to rely on those representation when ascertaining the degree of lawful conduct, such as designing around the claim invention."). Patent Owner's statements during prosecution contradict its arguments in the present proceeding.

We agree with Petitioner that in view of the prosecution history, limitation [1.5] requires only a relative slope determination, and a graded dopant concentration is enough to teach aiding carrier movement in a particular direction. Patent Owner's statements during prosecution of the parent '195 patent and '588 application, along with the specification of the '842 patent, support a determination that a graded dopant concentration is enough to teach aiding carrier movement in a particular direction. Petitioner's arguments about the prosecution of the '588 application are similarly persuasive.

The language of limitation [1.5] itself also supports our determination that a graded dopant concentration as taught in Kawagoe's Figure 17 is sufficient meet the limitation. In *ParkerVision, Inc. v. Qualcomm Inc.*, 903 F.3d 1354, 1361 (Fed. Cir. 2018), the Federal Circuit held that claims directed to devices "cover what a device is, not what a device does" (quoting *Hewlett-Packard Co. v. Bausch & Lomb Inc.*, 909 F.2d 1464, 1468 (Fed. Cir. 1990). In other words, a claim limitation directed to a device having a recited function requires "an apparatus that is 'reasonably capable' of performing the claimed function[]." *Id.* at 1361–62 (a device may be "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"). Challenged claim 1 is not a method claim, and limitation [1.5] recites structure for a semiconductor device, i.e. "at least one graded dopant concentration." Therefore, to effectively challenge limitation [1.5], Petitioner need only show "a graded dopant concentration" that is *capable* of "aid[ing] carrier movement from the first surface to the second surface of the substrate."

We turn to Patent Owner's first contention disputing Petitioner's showing as to Kawagoe. Patent Owner's arguments are based on its interpretation of limitation [1.5] as requiring that a graded dopant necessarily aids carrier movement. *See* PO Sur-reply 1–3, 6, 7 (citing *Transclean Corp. v. Bridgewood Servs., Inc.*, 290 F.3d 1364, 1373 (Fed. Cir. 2002)). We do not find this persuasive, for the reasons described above and further below. *Transclean* is distinguishable because it concerned "anticipation by inherent disclosure" which "is appropriate only when the reference discloses prior art that must necessarily include the unstated limitation." *Transclean Corp*., 29 F.3d 1364, 1373 (citing *Cont'l Can Co. v. Monsanto Co.*, 948 F.2d 1264, 1268–69 (Fed. Cir. 1991)). The challenges here are based on obviousness, and are not based on an assertion of inherent disclosure. To the contrary, as explained above, Petitioner argues Kawagoe's capability to aid carrier movement. *See ParkerVision*, 903 F.3d at 1361–62.

As to Patent Owner's argument that the '842 patent specification requires a specific dopant concentration (PO Resp. 16; PO Sur-reply 20–21), we find that the specification does not support that argument. Patent Owner relies on the statement that "the relative slope of the donor concentration throughout the base creates a suitable aiding draft electric field" (Ex. 1001, 3:2–4) and further argues

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

PO Sur-reply 20–21. We disagree with Patent Owner because the specification excerpts above describe relative slope and gradient. Further, the donor concentration is described in the context of a bipolar junction transistor (BJT) embodiment that is not encompassed by claim 1. *See* Tr. 26:1–8. In the BJT embodiment of the '842 patent, the graded dopant concentration moves carriers from emitter to collector, that is, *within* the active region. *See id.* at 25:9–16, 25:19–23. In contrast, claim 1 requires moving carriers *away* from the active region to the substrate. *See id.* at 25:17–18, 25:23–25; *cf. id.* at 65:14–66:2.

Patent Owner argues that, during prosecution, it "disagreed with the Examiner's conclusion that the claim at issue there (which never issued) should be rejected, but was not disagreeing with the relevant part of the Examiner's statement" that "[a] gradient is not the only force acting on a carrier." PO Sur-reply 18. As to the hypothetical opposing forces that Patent Owner asserts are missing from Petitioner's analysis, the specification, prosecution history, and prior art references do not mention such forces or a need to compensate for them. We agree with Petitioner that "[t]he challenged claims also do not require the graded dopant concentration be strong enough . . . to overcome a hypothetical resistance." Pet. Reply 16. Citing Kawagoe's disclosure (Ex. 1007, 6:2–11), Petitioner's counsel persuasively explained at oral hearing that "what it's telling us is that they've intentionally picked the gradient in Kawagoe so that it will handle whatever other fields and forces may be going on here to the extent you needed something else to make sure these electrons are attracted to the substrate." Tr. 22:15–23.

We disagree with Patent Owner that "Petitioner must show that" these hypothetical opposing forces "would *never* overwhelm the gradient." PO Sur-reply 8. Patent Owner also argues that "[t]he fact that a reference does not explicitly discuss a force does not mean that the force is absent or that a POSITA would disregard it." *Id.* Even if "it is undisputed that [some] resistance is '*always*' present" as Patent Owner argues (*id.* (citing Ex. 1052, 146:16–18 (emphasis by Patent Owner)), we disagree with Patent Owner that "[t]o carry its burden, Petitioner must affirmatively show that the other forces are absent or the gradient is stronger" (*id.*). Here, where the inventor "did not provide the type of detail in his specification that" Patent Owner "now argues is necessary in" Kawagoe, we find "that one skilled in the art would have known how to implement the features of the reference[]." *In re Epstein*, 32 F.3d 1559, 1568 (Fed. Cir. 1994).

In view of our interpretation of limitation [1.5] as discussed above, Patent Owner's argument as to the deficiencies of Dr. Blalock's testimony because he did not consider the magnitude of gradient slope or other possible forces acting on a carrier (*see* PO Resp. 16, 20–21) is not persuasive. On the other hand, based on our determination that a graded dopant concentration need only be capable of aiding carrier movement in order to satisfy limitation [1.5], we find that Dr. Glew's deposition testimony that "a field will provide a force in a direction aiding [] movement in the direction of the force. That's just basic physics" (Ex. 1052, 108:20–23) supports Petitioner's contention. S*ee* Pet. Reply 2. Demonstrating "a graded dopant concentration" that is capable of "aid[ing] carrier movement from the first surface to the second surface of the substrate" is a sufficient basis for challenging limitation [1.5], and for the reasons discussed above,

we are persuaded Petitioner has done so by showing a graded dopant concentration with a slope, in a particular direction, in Figures 17 and 23 of Kawagoe that is not only reasonably capable, but actually does, move carriers in the claimed direction.

We turn to Patent Owner's second contention, i.e., that Kawagoe only teaches using a graded slope to impede carrier movement. *See* PO Resp. 16. Patent Owner relies on Kawagoe's disclosure 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, 16:7–11) (emphasis by Patent Owner) and argues Dr. Blalock admitted that in Kawagoe, "SEUs[12] generate 'electrons created by an α-ray in the substrate body below the wells'" and "Kawagoe's electrons are below p-well 6p, and prevented from moving upward into p-well 6p." PO Resp. 24–25 (citing Ex. 1003 ¶ 91 n.5; Ex. 2057 ¶ 53).

We find that Kawagoe does not support Patent Owner's contention, and do not agree that Dr. Blalock incorrectly analyzed Kawagoe. Petitioner persuasively argues an "electric field will aid electron movement in one direction and impede electron movement in the opposite direction." Pet. Reply 7 (citing Ex. 1052, 83:13–89:13, 92:2–97:8, 102:2–109:14, 109:25–116:3, 121:19–123:15); *see also* Pet. Reply 10 ("because of the concentration gradient electrons are ***both*** 'attracted to the substrate body 2S' (i.e., movement aided) ***and*** 'prevented from entering the p-well' (i.e., movement inhibited)"). Dr. Glew's deposition testimony supports Petitioner. *See id.,* 103:25–104:4, 104:14–16, 105:22–106:6. Thus, we

[12] "SEU" refers to a "single event upset." PO Resp. 17 (citing Ex. 1007, 16:7–11).

agree with Petitioner that in Kawagoe, "an electric field aids carrier movement 'to the substrate body 2S' and impedes carrier movement in the opposite direction [from] 'entering the p-well.'" Pet. Reply 7 (citing Ex. 1007, 16:2–11, Figs. 17, 23; Pet. 25–32); *see id.* at 10 (citing Ex. 1052, 102:2–109:14; Ex. 1007, 16:2–11). Petitioner persuasively argues that "[f]or a semiconductor device as in Kawagoe to operate, there must be carriers in the active region," and as such, "the electric field from Kawagoe's graded concentration would impact carriers both in the substrate and anywhere in the graded dopant region." *Id.* at 7.

With respect to Patent Owner's argument that "Petitioner does not dispute Dr. Glew's . . . testimony that 'if two forces are acting on an object in opposite directions, both forces cannot aid its movement,'" we determine that this is not the relevant inquiry. PO Resp. 18 (citing Ex. 2057 ¶¶ 50–51); PO Sur-reply 2 ("[A] force also cannot push in one direction and 'aid movement' in the opposite direction."). Patent Owner's litigation position is more on point: "Electric drift fields are a well-known phenomenon that cause carriers to move, and a POSITA would have readily recognized that when a 'static unidirectional electric drift field' is present that it aids the movement of the minority carriers. If it isn't present, then it doesn't." Ex. 1020, 26; *see also id.* at 27 ("The drift field points to one direction and charge carriers, when free to move, respond to the drift field by moving in one direction or the other depending on their charge polarity."). More particularly, Patent Owner contends in the related litigation:

> Defendants argue that the claims do not recite a range of doping, a particular doping profile, or a particular result. But this is not the test for indefiniteness. While the claims require that the graded dopants create an electric field that aids movement of the carriers, *they do not require a specific range of doping, a*

> *particular doping field, or a particular result, and this information is not necessary to understand the scope of Dr. Rao's invention*.

Id. at 28 (emphasis added). We find that Patent Owner's arguments in this proceeding are inconsistent with its positions in related litigation, and unpersuasive. For similar reasons, we find that Dr. Glew's testimony concerning Nishizawa's[13] teaching on the probability of carriers from an alpha ray at the top of a device is not pertinent. *See* PO Resp. 24–25 n.10.

We turn to Patent Owner's third contention, i.e., that Petitioner improperly relies on Wang. Patent Owner contends Petitioner has not established public availability of Wang, "which purports to be from ***2008, i.e., four years after the critical date*** of the Challenged Patent." PO Resp. 26 (citing Ex. 1003 ¶ 92; Pet. ix; Ex. 1009, 429 (listing 2008 copyright date)). Petitioner responds that Wang's subject matter was "known before the priority date" because Nishizawa, which issued in 1995, "confirms that alpha-ray strikes generate electrons in the active region, and Patent Owner's expert confirmed that alpha ray strikes from cosmic rays were well known before" the earliest possible priority date of the '842 patent. Pet. Reply 14 (citing Ex. 1052, 82:6–83:7, 116:4–123:15; Ex. 2057, 30, n.4; PO Resp. 25–26).

We agree that Patent Owner's arguments relying on Nishizawa confirm that a person of ordinary skill in the art would have known before the '842 patent's priority date that alpha-ray strikes generate electrons in the active region, and therefore its argument as to Wang's date is not pertinent

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

to our inquiry. Further, Petitioner does not propose modifying Kawagoe in view of Wang, but rather contends a person of ordinary skill would have understood Kawagoe's electric field would interact with electrons to aid their movement towards the substrate. *See* Pet. Reply 15.

We turn to Patent Owner's fourth contention, i.e., that Kawagoe's electrons that are prevented from entering the p-well are not created near the surface. PO Resp. 27–28. Patent Owner relies on Dr. Glew's testimony that a person of ordinary skill would have understood that Kawagoe's reference to "electrons produced by the α-ray" is not describing electrons near the surface, because Nishizawa teaches the "probability of creation of electron-hole pairs is extremely low near the surface." *See id.* at 27 (citing Ex. 2060, 19:21–34, 20:19–22; Ex. 2057 ¶ 55). Patent Owner asserts Dr. Blalock's testimony about Kawagoe should be discredited for similar reasons. *See id.* at 28 (citing Ex. 2058, 147–148). Petitioner responds that Patent Owner's argument is largely irrelevant, because there are electrons in Kawagoe's active region regardless of whether an alpha ray strike ever occurs. Pet. Reply 13. Petitioner further argues that Nishizawa undercuts Patent Owner's argument that alpha ray strikes in Kawagoe would only produce electrons in the substrate below the well. *Id.*

We agree with Petitioner and find that Kawagoe's disclosure that "electrons [are] produced by the α-ray" is illustrative, and not limiting as to a person of ordinary skill's understanding of how Kawagoe's graded dopant concentration functions. Further, we agree with Petitioner that alpha ray strikes are not even required for Kawagoe's graded dopant concentration to create an electric field that will have an effect on a carrier depending on its charge polarity, notwithstanding Patent Owner's assertion that "the alpha-

particle immediately after irradiation to the surface of a semiconductor body has an energy of several MeV" and "the probability of creation of electron-hole pairs is extremely low near the surface" (PO Resp. 27 (citing Ex. 2057 ¶¶ 55; Ex. 1007, 16:7–11; Ex. 2060, 19:21–34, 20:19–22). Under *ParkerVision*, the relevant inquiry is whether the graded dopant concentration is *capable* of performing the claimed limitation, *not* how likely the claimed limitation is to be performed or occur.

Further, we find that Nishizawa does not support Patent Owner's position. Nishizawa discloses

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

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

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

Id. at 19:56–67 (emphasis added). We find persuasive Petitioner's argument that even if an alpha ray strike were required, Nishizawa indicates that the alpha ray strike could produce electrons near the surface of the CMOS device. *See* Pet. Reply 13–14.

We turn to Patent Owner's fifth contention, i.e., that Kawagoe's teaching about a gradient only refers to gradients and carriers outside the active region. PO Sur-reply 9. According to Patent Owner, "[t]he Petition itself confirms that Kawagoe's teaching 'refers to electrons produced in the large substrate body below the wells.' The carriers Kawagoe discusses are 'prevented from entering the p-well,' and are thus below it." *Id.* (citing Pet. 28, n.9; PO Resp. 24). Patent Owner further contends that "Dr. Glew testified that Kawagoe only describes that this dopant gradient is able to keep SEU electrons out of the well,' and says nothing about drawing carriers '*from* the . . . active regions.'" *Id.* at 10 (citing Ex. 1052, 121:11–17, 122:6–9). Patent Owner also argues that "Petitioner offers no analysis of Kawagoe's electric field to show that it has the same effect in the active region as further down" (*id.*) and that the Petition incorrectly maps the challenged claim to Kawagoe. *Id.* at 11–12. Patent Owner also belatedly shifts position and argues that the active region is the well region. *Id.* at 13 (citing Ex. 1052, 24:1–9) ("as Dr. Glew explained, Petitioner is ignoring Figure 5A. 'Looking back at 5A, one can see a p-well and an n-well. … [S]ources and drains are of the opposite type of well or active area they're formed in. So if I have an n-type source and drain, it will be formed in a p-type [active] region.'" (alterations by Patent Owner)).

We find that Patent Owner first presents these arguments in its Sur-reply. A sur-reply "may only respond to arguments raised in the preceding brief." Patent Trial and Appeal Board Consolidated Trial Practice Guide, 74 (Nov. 2019) ("CTPG"), citing 37 C.F.R. §42.23. We decline to consider new arguments presented by Patent Owner in its Sur-reply. Because Patent Owner has not shown where its arguments were presented in Patent Owner's

Response, and due to the untimeliness of Patent Owner's arguments, we determine that Petitioner was denied a full and fair opportunity to respond to these arguments.

Nevertheless, even if we were to consider these belated arguments, we would not be persuaded because, for the reasons discussed for limitation [1.2] *supra*, we agree with Petitioner's position that "the 'doping type' of the 'first active region'" is "the doping type of the associated *source and drain regions*," which is supported by the underlying evidence in Wolf. Pet. Reply 18 (emphasis added); *see* Ex. 1008B Fig. 5-1(a), 298–99).

In view of the foregoing, we find that Kawagoe discloses limitation [1.5].

f. Conclusion as to Claim 1

For the foregoing reasons, we determine that Petitioner establishes by a preponderance of the evidence that claim 1 is unpatentable as obvious over Kawagoe.

3. Independent Claim 9

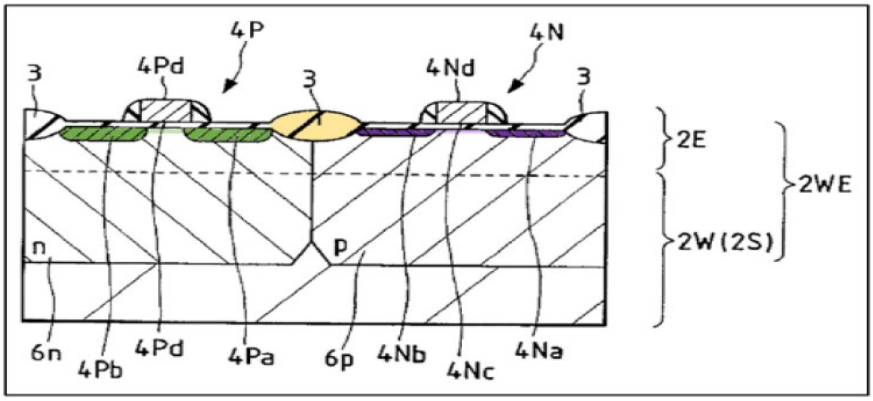
Petitioner's arguments and evidence for claim 9 (Pet. 35–37) are substantially the same as Petitioner's arguments and evidence for claim 1 (*id.* at 13–30).

Patent Owner does not present argument for independent claim 9, beyond what is presented for independent claim 1. In view of the foregoing discussion, we determine that Petitioner establishes by a preponderance of the evidence that independent claim 9 is unpatentable as obvious over Kawagoe.

4. Dependent Claims 7 and 15

Claims 7 and 15 recite "wherein the first active region and second active region are each separated by at least one isolation region." Petitioner

maps Kawagoe's field insulating film 3, annotated in yellow in Kawagoe's Figure 23, as reproduced below, to the claimed isolation region.



The figure reproduced above depicts Petitioner's annotated version of Kawagoe's Figure 23 with field insulating film 3 highlighted yellow. Pet. 35.

> Patent Owner argues
>
> the Petition fails to appreciate that regions 4Na and 4Nb, which "are regions for forming the source-drain regions of the nMOS 4N" "are made as deep as about 0.5 μm and ***formed in the range of the thickness of the epitaxial layer 2E***." Kawagoe provides similar disclosure regarding regions 4Pa and 4Pb. Thus, a POSITA would have understood that the first and second active regions extend to about the depth of the epitaxial layer 2E and abut each other laterally, and therefore they are not separated by Kawagoe's field insulating film 3, as required by claims 7 and 15.

PO Resp. 34–35 (citing Ex. 1007, 8:66–67, 9:3–6, 9:47–53; Ex. 2057 ¶ 64). Accordingly, Patent Owner contends that "[t]he field insulating film 3 is formed '[o]ver the principal surface of the epitaxial layer 2E' and a POSITA would have understood that it does not extend deep enough to separate the two active regions." *Id.* at 35 (citing Ex. 2057 ¶ 64; Ex. 1007, 8:40–42).

Petitioner replies that Patent Owner's "argument rests on an unsupported assumption that claims 7 and 15 require the isolation region to separate the first and second active regions at *all points along their respective depth*." Pet Reply 20 (citing PO Resp. 33–35) (emphasis added). According to Petitioner, "the claims do not specify where and to what extent the isolation region must separate the first and second active regions." *Id.*

Petitioner also argues Patent Owner misunderstands Kawagoe's geometry. Pet. Reply 20. First, Petitioner argues epitaxial layer 2E can range from 0.3 μm to 5 μm, the top end of the range being significantly larger than the maximum 0.5 μm depth of semiconductor active region 4Na, 4Nb, 4Pa, and 4Pb. *Id.* at 21. Second, Petitioner argues "Kawagoe teaches that insulating film 3 is formed via [local oxidation of silicon, "LOCOS"] which (according to Patent Owner's expert) 'consumes a portion of the silicon and works its way downward.'" *Id.* at 21 (citing Ex. 1052, 139:2–142:2).

Finally, Petitioner contends that, even if the "claims require[ed] separation on the full depth of the active regions ***and*** if PO were right about the active regions protruding deeper into the device than insulating film 3, Kawagoe would ***still*** teach an 'isolation region' that separates the first and second active regions." Pet. Reply 21. Petitioner points to Kawagoe's teaching "a channel stopper region is formed below the field insulating film 3, although not shown." *Id.* at 22 (citing Ex. 1007, 8:43–45).

We find Petitioner has the better position, for the simple reason that the claims do not require the "isolation region" to completely separate the active regions, that is, that the isolation region extend to a depth that is the same as or deeper than the depth of the active regions. The claimed

"isolation region" is not defined or set forth in the specification, only in the claims.

For the foregoing reasons, we determine that Petitioner establishes by a preponderance of the evidence that claims 7 and 15 are unpatentable as obvious over Kawagoe.

5. Remaining Dependent Claims

We have reviewed Petitioner's arguments and evidence for remaining claims 2, 4–6, 8, 10, 12–14, and 16–18, and we are persuaded that the cited portions of Kawagoe teach what Petitioner asserts they teach and that Dr. Blalock's testimony sufficiently supports Petitioner's arguments. *See* Pet. 32–40. Patent Owner does not present arguments for these claims beyond those presented for independent claim 1. In view of the foregoing discussion, we determine that Petitioner establishes by a preponderance of the evidence that these dependent claims are unpatentable as obvious over Kawagoe.

F. Obviousness Based on the Combination of Wieczorek and Wolf

Petitioner challenges claims 1–3, 5–11, and 13–18 as obvious based on the combination of Wieczorek and Wolf. Pet. 5, 40–62. Patent Owner disagrees. *See generally* PO Resp. For the reasons discussed below, Petitioner has established by a preponderance of evidence that claims 1–3, 5–11, and 13–18 are obvious based on the combination of Wieczorek and Wolf.

1. Wieczorek (Ex. 1006)

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. Petitioner relies on Wieczorek's

description of a conventional prior-art CMOS device, not its disclosed improvement. Pet. 40.

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, a retrograde channel dopant profile is desirable, but "very difficult to obtain." *Id.* Wieczorek states 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.

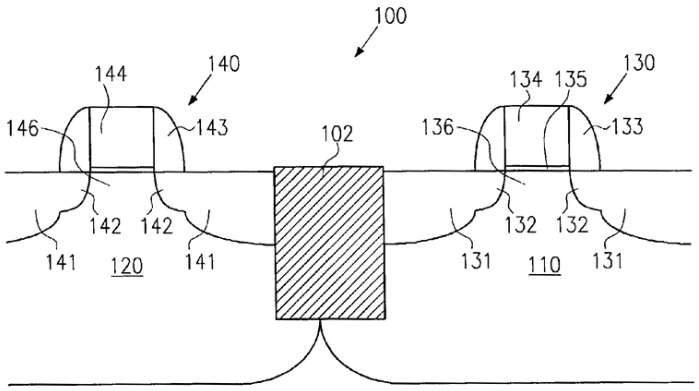


FIG.1b
(Prior Art)

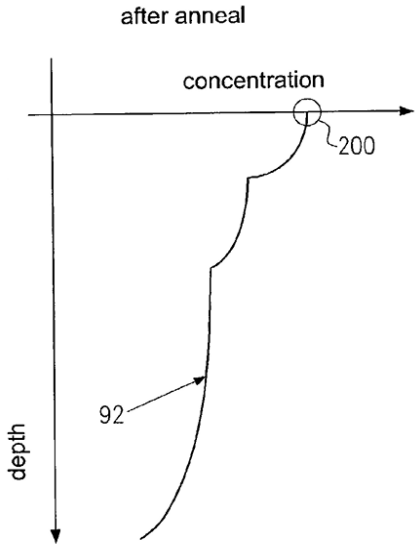


FIG.2b
(Prior Art)

Wieczorek Figure 1b shows a conventional semiconductor device at an early manufacturing stage, including shallow trench isolation 102 separating N-

well structure 120 from P-well structure 110. Ex. 1006 ¶¶ 7, 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. 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 (Ex. 1008)*

Wolf is a four-volume textbook titled "Silicon Processing for the VLSI Era." Ex. 1008.

3. Reason to Combine Wieczorek and Wolf

Petitioner argues a person of ordinary skill in the art would have had a reason to combine the teachings of Wieczorek and Wolf because Wieczorek discloses "a conventional prior-art CMOS device" and "Wolf is a well-known textbook that teaches known fundamental features and concepts related to semiconductor manufacturing, with particular emphasis on CMOS devices." Pet. 40–41. Petitioner further argues Wieczorek discloses "[a] typical process flow for forming the semiconductor device 100" which is "a complementary MOS transistor pair." *Id.* at 40 (citing Ex. 1006 ¶ 12, Fig. 1b). Dr. Blalock explains that a person of ordinary skill in the art would have looked to Wolf for details on how to manufacture the conventional CMOS devices of Wieczorek. Ex. 1003 ¶ 138; Ex. 1008A, 807–40. Based on Petitioner's showing, we find that a person of ordinary skill in the art would have been motivated to combine the teachings of Wieczorek and Wolf with a reasonable expectation of success.

4. Claim 1

Petitioner provides detailed analysis showing where it contends each limitation of claim 1 is taught in the combination of Wieczorek and Wolf. Patent Owner does not dispute Petitioner's showing, except with regard to limitation [1.5]. *See* PO Resp. 29–31. We focus our discussion on that disputed limitation.

a. [1.5] "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."

Petitioner contends the combination of Wieczorek and Wolf teaches this limitation. Petitioner contends channel region 136 of Wieczorek's nMOS transistor 130, formed at the top surface of the substrate shown in Figure 1b, is a portion of the first active region. Pet. 50 (citing Ex. 1006 ¶¶ 4, 12–13; Ex. 1008B, 298–301, Fig. 5-2; Ex. 1003 ¶ 140. Petitioner contends Wieczorek discloses a doping profile in Figure 2b which shows the dopant concentration is highest at the surface of the substrate and decreases with depth. *Id.* at 51 (citing Ex. 1003 ¶ 141). Therefore, Petitioner contends, channel region 136 has a graded dopant concentration. *Id.* Petitioner further contends Wieczorek discloses channel region 146 of pMOS transistor 140 also has a graded dopant concentration. *Id.* at 52 (citing Ex. 1006 ¶¶ 4, 9, 11–13, Figs. 2a, 2b; Ex. 1008B, 298–301, Fig. 5-2. Petitioner further contends Wieczorek's downward-sloping graded dopant concentration aids carrier movement from the first surface to the second surface of the substrate. *Id.* at 52–53.

Patent Owner argues Petitioner's Wieczorek-based challenge fails for similar reasons to the challenge based on Kawagoe. PO Resp. 29. Patent

Owner's argument is based on its interpretation of limitation [1.5] as requiring that the graded dopant concentration "aid carrier movement" and its contention as to the effect of its statements during prosecution history, as discussed in Section III.E.2.e. *supra.* Patent Owner further asserts "Dr. Blalock admitted that he did not calculate the slope of the graded concentration curve in Wieczorek" and "it would have been impossible for Dr. Blalock to make such a calculation, because the dopant gradient Petitioner points to in Figure 2B (and Wieczorek generally) does not have any values from which one could calculate a slope." *Id.* at 30 (citing Ex. 2058, 195; Ex. 2057 ¶ 60).

Having considered the evidence and arguments of both parties, we find that Petitioner demonstrates the combination of Wieczorek and Wolf teaches limitation [1.5]. For substantially the same reasons set forth above in Section III.E.2.e., we find Patent Owner's arguments unpersuasive. We interpret limitation [1.5] under *ParkerVision*, as described above, and therefore Petitioner need only show a graded dopant concentration that is capable of aiding carrier movement; Petitioner is not required to show a particular slope for Wieczorek's graded dopant concentration. For the reasons set forth in the context of our discussion of the Kawagoe-based challenge, and Petitioner's detailed showing, we find that the combination of Wieczorek and Wolf discloses limitation [1.5].

b. Conclusion as to Claim 1

For the foregoing reasons, we determine that Petitioner establishes by a preponderance of the evidence that claim 1 is unpatentable as obvious over the combination of Wieczorek and Wolf.

5. Claims 2, 3, 5–11, and 13–18

We have reviewed Petitioner's arguments and evidence for claims 2, 3, 5–11, and 13–18 and we are persuaded that the cited portions of Wieczorek and Wolf teach what Petitioner asserts they teach and that Dr. Blalock's testimony sufficiently supports Petitioner's arguments. *See* Pet. 32–40. Patent Owner does not present arguments for these claims beyond that presented for independent claim 1. In view of the foregoing discussion, we determine that Petitioner establishes by a preponderance of the evidence that these dependent claims are unpatentable as obvious over the combination of Wieczorek and Wolf.

G. Remaining Challenges II and IV

For the reasons discussed above, Petitioner has shown by a preponderance of the evidence that claims 1–18 of the '842 patent are unpatentable. We have, thus, addressed all of the challenged claims. *See* 35 U.S.C. § 318(a) (requiring the Board to "issue a final written decision with respect to the patentability of any patent claim challenged by the petitioner and any new claim added under section 316(d)"); *see also SAS Inst. Inc. v. Iancu*, 138 S. Ct. 1348, 1359 (2018) (holding that a petitioner "is entitled to a final written decision addressing all of the claims it has challenged"). Accordingly, we need not and do not decide whether Petitioner has shown by a preponderance of the evidence that claims 1, 2, 4–10, and 12–18 are unpatentable over the combination of Kawagoe and Gupta, or that claims 1–3, 5–11, and 13–18 are unpatentable over the combination of Wieczorek, Wolf, and Gupta. *Cf. In re Gleave*, 560 F.3d 1131, 1338 (Fed. Cir. 2009).

IV. CONCLUSION

Petitioner has shown by a preponderance of the evidence that the challenged claims are unpatentable as summarized below:

Claim(s)	35 U.S.C. §	Reference(s)/ Basis	Claim(s) Shown Unpatentable	Claim(s) Not Shown Unpatentable
1, 2, 4–10, 12–18	103(a)	Kawagoe	1, 2, 4–10, 12–18	
1, 2, 4–10, 12–18	103(a)	Kawagoe, Gupta[14]		
1–3, 5–11, 13–18	103(a)	Wieczorek, Wolf	1–3, 5–11, 13–18	
1–3, 5–11, 13–18	103(a)	Wieczorek, Wolf, Gupta[15]		
Overall Outcome			1–18	

This Decision may discuss confidential matters because it discusses certain papers and exhibits that the parties filed under seal. Accordingly, we issue the present decision under seal, and we order the parties, within ten days after the issuance of this decision, to file a joint motion to seal explaining why this decision should remain under seal and including a redacted version of this decision that can be made publicly available. The present decision shall remain under seal until the joint motion to seal the present decision is resolved.

[14]As explained above, because we determine that challenged claims 1, 2, 4–10, and 12–18 are unpatentable over Kawagoe, we decline to address this ground.

[15] As explained above, because we determine that challenged claims 1–3, 5–11, and 13–18 are unpatentable over the combination of Wieczorek and Wolf, we decline to address this ground.

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V. ORDER

For the reasons given, it is

ORDERED that Petitioner has shown that claims 1–18 of the '842 patent are unpatentable;

FURTHER ORDERED that, no later than ten days after the issuance of this decision, the parties shall file a joint motion to seal, explaining why this decision should remain under seal, and including a redacted version of this decision that can be made publicly available;

FURTHER ORDERED that the present decision shall remain under seal until the joint motion to seal the present decision is resolved; and

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

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