**PUBLIC VERSION**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

**BEFORE THE PATENT TRIAL AND APPEAL BOARD**

CIRRUS LOGIC, INC.;
OMNIVISION TECHNOLOGIES, INC.; AND
Petitioner,

v.

GREENTHREAD, LLC,
Patent Owner.

Case No. IPR2024-00001
Patent No. 10,734,481

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# PETITIONER'S REPLY TO PATENT OWNER RESPONSE

## LIST OF EXHIBITS

| Exhibit | Description |
|---|---|
| 1001 | U.S. Patent No. 10,734,481 to Rao (the "'481 Patent") |
| 1002 | Prosecution History of the '481 Patent |
| 1003 | Declaration of Sanjay Banerjee, PhD |
| 1004 | Curriculum Vitae of Sanjay Banerjee, PhD |
| 1005 | Publication Declaration of Sean O'Bryan for Maziasz ("O'Bryan Decl.") |
| 1006 | U.S. Patent Application Publication No. 2003/0183856 to Wieczorek ("Wieczorek") |
| 1007 | U.S. Patent No. 6,043,114 to Kawagoe, et al. ("Kawagoe") |
| 1008A | Wolf and Tauber, *Silicon Processing For The VLSI Era*, Vol 1, Lattice Press (2000) ("Wolf.1") |
| 1008B | Wolf and Tauber, *Silicon Processing For The VLSI Era*, Vol 2, Lattice Press (2000) ("Wolf.2") |
| 1008C | Wolf and Tauber, *Silicon Processing For The VLSI Era*, Vol 3, Lattice Press (2000) ("Wolf.3") |
| 1008D | Wolf and Tauber, *Silicon Processing For The VLSI Era*, Vol 4, Lattice Press (2000) ("Wolf.4") |
| 1009 | Wang and Agrawal, *Single Event Upset: An Embedded Tutorial*, 21st Intl Conf on VLSI Design, IEEE 2008 ("Wang") |
| 1010 | U.S. Patent No. 4,481,522 ("Jastrzebski") |
| 1011 | Publication Declaration of Martin L. Knott for Rabaey ("Knott Decl.") |
| 1012 | Publication Declaration of Alyssa G. Resnick for Wolf.1 and Wolf.2 ("Resnick Decl.") |
| 1013 | Publication Declaration of Rachel J. Watters for Wolf.3 and Wolf.4 ("Watters Decl.") |
| 1014 | U.S. Patent No. 6,163,877 ("Gupta") |
| 1015 | U.S. Patent No. 6,534,805 ("Jin") |
| 1016 | Excerpts from the Prosecution History of U.S. Patent No. 8,421,195 (the "'195 Patent") |
| 1017 | Patent Owner's Proposed Constructions |
| 1018 | Blank |
| 1019 | Blank |
| 1020 | Patent Owner's Responsive Claim Construction Brief |
| 1021 | Blank |

| Exhibit | Description |
|---|---|
| 1022 | Sze, *Semiconductor Devices Physics and Technology*, 2d Ed., John Wiley & Sons (2002) |
| 1023 | Maziasz and Hayes, *Layout Minimization of CMOS Cells*, Kluwer Academic Publishers (1992) ("Maziasz") |
| 1024 | U.S. District Courts – Case Statistics, obtained at https://www.uscourts.gov/statistics-reports/analysis- reports/ federal-court-management-statistics, dated June 30, 2023 |
| 1025 | Rabaey et al., *Digital Integrated Circuits, A Design Perspective*, Prentice Hall Electronics and VLSI Series (2003) ("Rabaey") |
| 1026 | Gregory and Shafer, "Latch-Up In CMOS Integrated Circuits," IEEE Transactions on Nuclear Science, Volume 20, Issue 6 (1973) |
| 1027 | U.S. Patent Application Publication No. 2007/0045682 to Hong et al. ("Hong") |
| 1028 | Excerpts from the Prosecution History of U.S. Patent Application Publication No. 10/934,915 (the "'915 App.") |
| 1029 | Excerpts from the Prosecution History of U.S. Patent No. 9,190,502 (the "'502 Patent") |
| 1030 | Excerpts from the Prosecution History of U.S. Patent Application Publication No. 13/854,319 (the "'319 App.") |
| 1031 | U.S. Patent No. 4,160,985 to Kamins et al. ("Kamins") |
| 1032 | McGraw-Hill Dictionary of Scientific and Technical Terms (2003) |
| 1033 | Excerpts from the Prosecution History of U.S. Patent No. 11,121,222 (the "'222 Patent") |
| 1034 | U.S. Patent No. 9,647,070 to Rao (the "'070 Patent") |
| 1035 | U.S. Patent Application Publication No. 2003/0030488 to Hueting *et al*. ("Hueting") |
| 1036 | Publication Declaration of Sylvia Hall-Ellis for Wolf |
| 1037 | Law360 Article "Stays Pending IPR In Del. District Courts Are Here To Stay," Kraning and Del Dotto, March 11, 2022. |
| 1038 | Dec. 21, 2022 Preliminary Claim Constructions in 6:22-CV-00105 |
| 1039 | Oct. 31, 2022 Giapis Declaration, 6:22-CV-00105 |
| 1040 | Blank |
| 1041 | Blank |
| 1042 | U.S. Patent No. 6,614,560 to Silverbrook ("Silverbrook") |
| 1043 | Blank |

| Exhibit | Description |
|---|---|
| 1044 | Wong et al., "CMOS Active Pixel Image Sensors Fabricated Using a 1.8V, 0.25 um CMOS Technology." |
| 1045 | Email dated December 22, 2023 |
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| 1058 | Blank |
| 1059 | Blank |
| 1060 | Supplemental Declaration of Sanjay Banerjee, PhD |
| 1061 | Sze, Semiconductor Devices: Physics and Technology, Second Edition 1985, excerpted ("Sze") |
| 1062 | Streetman and Banerjee, Solid State Electronic Devices, Sixth Edition 2006, excerpted ("Streetman") |
| 1063 | Deposition Transcript of Alexander Glew, Ph.D., P.E., taken on Oct. 16, 2024 |
| 1064 | Declaration of Douglas Holberg in Application No. 17/728,588 (Aug. 1, 2024) |
| 1065 | R. C. Baumann, *Soft Errors in Commercial Integrated Circuits*, 14(2) Int'l J. High Speed Elect. & Sys. 299-399 (2004) |
| 1066 | Confidential Deposition Transcript of Mohan Rao, Ph.D., taken on Oct. 23, 2024 |
| 1067 | RPX Rational Patent FAQs |
| 1068 | A. S. Grove, *Physics and Technology of Semiconductor Devices*, excerpted (1067) |
| 1069 | Deposition Transcript of Alexander Glew, Ph.D., P.E., taken on July 16, 2024 |
| 1070 | Amendment and Response to Office Action in Application No. 17/728,588 (Aug. 1, 2024) |
| 1071 | Wolf Vol. 2 Supplement |

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## I. INTRODUCTION

Petitioner demonstrated that the challenged claims are invalid. Greenthread's response defies the intrinsic record, including the well-established technical representation that Greenthread itself made during prosecution: that graded dopant concentration results in a "built-in" electric field that will aid carrier movement. Faced with compelling prior art, Greenthread now mischaracterizes basic semiconductor physics and rewrites the claims to support its position. These apparatus claims recite structural components, and do not require the device to be "on." Further, Greenthread's argument that licenses show secondary considerations are wholly unsupported, and its rehash of its failed privity arguments warrant no reconsideration.

## II. GREENTHREAD'S "AID CARRIER MOVEMENT" ARGUMENTS HINGE ON FLAWED PREMISES

All challenged claims require a "graded dopant concentration *to aid carrier movement from the first surface to the second surface of the substrate*." Ex.1001, cl. 1. The "*from…to…*" language specifies that the graded dopant concentration must have particular ***direction*** to aid carrier movement in the required direction. As Petitioner demonstrated, that is merely a function of whether the gradient's slope is downward (i.e., negative) or upward (positive) going deeper into the device. The Petition demonstrates why the cited art satisfies this feature. Pet. 28-39; 63-68.

Greenthread now isolates a subset of that term—"aid carrier movement"—and alleges that ***"[o]ther forces"*** must be "***measure[d]*** or ***"compare[d]"*** with "the ***magnitude*** of the force exerted by the gradient[]" to determine whether the gradient "aids carrier movement." POR 7-8. Greenthread's arguments hinge on incorrect understanding of semiconductor physics and a flawed claim interpretation. Moreover, this new argument is flatly inconsistent with statements made to the USPTO, which the sole inventor (Dr. Rao) reviewed and ensured were accurate before they were filed.

### A. "Aid Carrier Movement" Does Not Depend Upon "Measuring" and "Comparing" Forces

The intrinsic record lends no support for Greenthread's position that the "magnitude" of the gradient plays any role in the claims. On the contrary, Greenthread represented to the USPTO that a graded concentration sloped in a particular direction "necessarily" moves carriers. Dr. Banerjee confirms that representation in the intrinsic record is technically accurate. Greenthread's expert opinions hinge on flawed and irrelevant premises, and its additional evidence are mischaracterizations.

#### 1. Greenthread Admitted that a Graded Dopant Concentration Sloped in a Specific Direction Aids Carrier Movement

*Greenthread itself* represented that a graded dopant concentration sloped in a particular direction necessarily aids carrier movement, regardless of other alleged

factors. During prosecution, as to pending claims that were identical in relevant respects, the Examiner observed that "***any magnitude*** of the drift electric field, ***however small, reads on the claim.***" Ex.1016, 139-40. Greenthread did not dispute this representation.

Subsequently, the Examiner rejected the claims under §112, theorizing that "movement of minority carriers is affected by multiple forces and fields…[so] it does not appear that simply the presence of 'a unidirectional drift field' itself can achieve 'drawing all minority carriers from said surface to said substrate' "without knowing other parameters of the device." Ex.1016, 269-70, 289. To overcome the §112 rejection, Greenthread made clear it "***disagrees*** with this position." *Id.* Greenthread told the USPTO that (1) "the graded dopant concentration <u>itself</u> creates a 'built-in' electrical field that forces the movement of carriers into a particular direction," and that (2) "a unidirectional drift (electric) field <u>necessarily</u> affects <u>all</u> the present minority carriers in the same way – moving all minority carriers in the same direction because of the unidirectional drift." Ex.1016, 289-90 (emphasis original); Pet. 35-36. Greenthread added that (3) "[d]epending 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)," and that (4) the "inherent 'built-in' unidirectional electric field" created by the concentration gradient "is ***the*** additional parameter for

ensuring that all minority carriers are being moved in one direction." Ex.1016, 289-90. Greenthread backed these assertions with the textbook of Intel founder Andy Grove—a well-regarded technical authority. *Id.*, 289. Ex.1063-Glew-Tr., 183:8-184:7. Dr. Rao confirmed that he reviewed all Office Action responses for technical accuracy. Ex.1066-Rao-Tr., 15:2-16:2, 19:13-20.[1]

Shackled by this prosecution record, Greenthread resorts to dismissing the importance of file histories generally, as "often lack[ing] the clarity of the specification." POR 11. But there is nothing ambiguous about Greenthread's admissions here. Greenthread clearly argued to the USPTO that "particular slope" is not a reference to the slope's magnitude, but ***only its direction*** ("down" or "up"), Ex.1016, 289, but now attempts to evade these statements. POR 12-13. When Greenthread made these same arguments in another IPR proceeding, the Panel correctly noted that these prosecution "***statements speak for themselves***." *Monolithic Power Systems, Inc. v. Greenthread, LLC*, IPR2024-00468, Paper 25 at 14-15 (P.T.A.B. Aug. 20, 2024) ("195-Monolithic D.I.").

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[1] In a related proceeding, the Panel acknowledged "the statements made by [Greenthread] during prosecution…***contradict*** its arguments in the present proceeding." *Monolithic Power Systems, Inc. v. Greenthread, LLC*, IPR2024-00470, Paper 25 at 29 (P.T.A.B. Aug. 20, 2024) ("222-Monolithic D.I.").

Tellingly, nothing in the specification suggests measuring and comparing various forces, let alone in connection with "to aid carrier movement." When the Examiner issued the §112 rejection above, Greenthread did not identify specification disclosures of "magnitude" or "intrinsic resistance." Instead, Greenthread overcame the written description rejection by advancing the ***same inherency*** argument it now rejects. Ex.1016, 289.[2]

Greenthread now cites the specification's discussion of ***relative slope***, POR 8-9, but that merely refers to ***slope direction*** (increasing or decreasing), not magnitude. Indeed, Greenthread recently represented to the USPTO that the specification's reference to "relative slope" means "***nothing more than the fact that one-side is relatively lower than the other side***." Ex.1070-Aug-2024-Remarks, 9; Ex.1064-Aug-2024-Holberg-Declaration, 5. The specification also provides exemplary gradient slopes (*e.g.*, Ex.1001, 2:66-3:5), but that does not

[2] Likewise, in response to a §112 rejection in a continuation application, Greenthread and its expert responded "[i]n order to describe how the term 'gradient' is utilized and described and supported in the Specification," but made no mention of *magnitude*. Ex.1070-Aug-2024-Remarks, 9-10.

suggest that carrier movement hinges on the *magnitude* of those slopes.[3] The intrinsic record thus completely undermines Greenthread's present argument that the slope magnitude must be "measure[d]" and "compare[d]" with alleged other forces.

### 2. Greenthread's Litigation Positions Undermine Its Arguments Here

As part of its patent assertion effort, Greenthread reiterated its prosecution statements in its *Markman* briefing to avoid an indefiniteness challenge. *Here*, Greenthread says the claims relate to "'a complex electronic device, [where] movement of minority carriers is affected by multiple forces and fields." POR 9. In contrast, *during litigation*, Greenthread urged that "[t]o aid the movement" is a simple term that is readily understood by POSITAs and lay persons alike." Ex. 1020, 25. Greenthread *reiterated*—without qualification—that "***[w]hen the dopant concentration is graded in a particular direction, other charge carriers will move*** in the gradient direction (or opposite direction) depending on the charge carrier's

[3] In response to similar arguments, the Panel in the related proceeding observed that Greenthread "does not direct us to any discussion in the [specification] regarding a specific slope value that is necessary to 'aid the movement of minority carriers,'" or "to any authority suggesting we should demand more from the prior art disclosure…than is provided in the [specification]." 195-Monolithic D.I., 16.

polarity." *Id.*, 2; *see also* Ex.2057, ¶33 (Dr. Glew providing the ***exact same*** representation). Greenthread further explained, "[w]hile 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***," which are beyond "the scope of Dr. Rao's invention." Ex. 1020, 28.

Greenthread provided the following analogy to illustrate the claim scope: "if a claim recites: a wheelchair ramp to aid movement of a wheel chair from a first level to a ground level. There is ***no requirement*** that the claim specify the length or ***slope of the ramp*** as long as it allows the wheelchair user to get to ground level," *id.*, 27-28. ***"[N]obody would dispute that a wheelchair ramp 'aids the movement'*** of someone in a wheelchair." *Id.*, 25; *see id.*, 28 (no "*particular result*" required).

Greenthread's change-of-course from the litigation to IPR context is a classic "effort[] to twist claims, like a nose of wax, in one way to avoid invalidity and another to find infringement," which the Board should reject. *Data Engine Techs., LLC v. Google LLC*, 10 F.4th 1375, 1381 (Fed. Cir. 2021).

#### 3. Greenthread's Prior Representations Were Technically Accurate

The basic fundamentals of semiconductor physics confirm what Greenthread admitted during prosecution: that a dopant concentration sloped in a particular

direction naturally results in carrier movement.[4] Ex.1060-Banerjee-Supp.-Decl., ¶¶10-32. As Dr. Banerjee explains (backed by well-regarded semiconductor textbooks), a graded dopant concentration will induce a static, or "built-in," electric field in a particular direction (depending on the dopant type). *Id.*, ¶¶21-27. In turn, that static field superimposes a force onto minority carriers, thereby causing those carriers to *move* in a particular direction (depending on charge type), based on a phenomenon called "carrier drift"—that is, to *aid carrier movement* in that direction. *Id*. Further, carriers do not need to overcome any opposing forces before they move. Rather, in a doped semiconductor region, at room temperatures, carriers in the conduction band of a silicon atom are not bound, but are *free to move*. *Id.*, ¶¶12-20. Indeed, such carriers are *constantly moving* (i.e., in "Brownian" motion) due to thermal effects. *Id.*; Ex.1003-Banerjee-Orig.-Decl., ¶95.

Critically, the "*built-in* electric field" stemming from the graded dopant concentration is "***static***" (i.e., it is always present, and does not require an external

[4] Greenthread's assertion that Dr. Banerjee is unreliable, POR 30-33, lacks merit. Greenthread quibbles that Dr. Banerjee did not confirm how many times the Wolf textbook was cited, but nothing about this undermines his substantive analysis, and Greenthread does not even dispute that Wolf is a well-regarded authority. What is unreliable is *Dr. Glew's* analysis. *See* §II.A.4.

voltage). Ex.1060-Banerjee-Supp.-Decl., ¶¶21-27; Pet. 28-39, 63-68. This is consistent with Greenthread's admission during prosecution that the "'built-in electrical field" *alone* "forces the movement of carriers in a particular direction."[5] Ex.1016, 289-90.

#### 4. Dr. Glew's Analysis Hinges on Flawed Premises

Faced with invalidating prior art, Greenthread (through Dr. Glew) now argues that the "magnitude" of the slope of the graded dopant concentration "plays a substantial role, because a small gradient may not be sufficient to overcome the resistance." Ex.2057, ¶50. In his declaration, Dr. Glew identifies "intrinsic resistance of silicon," and vaguely references "other external forces," but does not identify them. *Id.* Notably, he fails to provide technical foundations of his analysis and cites no technical authority to support his opinions. As discussed below, his analysis is riddled with flaws regarding basic semiconductor physics.

He testified that "the mere presence of electric field ***isn't sufficient*** to cause electrons to become charge carriers," but that "***a threshold voltage***" is needed ***"to***

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[5] Indeed, Greenthread explained during prosecution that "the ***claimed invention*** relates to…devices which include graded dopant concentrations in regions capable of providing a localized drift electric field ***without the application of an external potential***." Ex.1016, 128.

***liberate an extra electron from a crystal structure.***" Ex.1063-Glew-Tr., 105:6-9, 107:8-10. He stressed that a "small enough voltage won't make an electron free or liberate it from the atom it's bonded to." *Id.*, 108:6-8; 128:14-17. That theory is fundamentally wrong because the extra electrons in a doped semiconductor are not bonded to silicon atoms, but are free to move, and already in Brownian motion. *See* §IIA.3 above.

Not surprisingly, Dr. Glew struggled to explain what this other "threshold voltage" is and how it "liberates" the extra electron from the lattice. He initially distinguished it from the well-understood ***threshold voltage $V_T$ that is applied to the gate*** to turn a transistor "on."[6] Ex.1063-Glew-Tr., 107:2-22. But he later conflated the two voltages, testifying that "the *gate voltage needs to free the electrons* and holes from the crystal lattice." *Id.*, 147:2-9; 145:10-14 (alleging the static electric field moves carriers "*when the gate…voltage applied* to it [is] of sufficient magnitude."). Finally, he alleged he did not opine on whether such a voltage is applied, or would cause extra electrons to be liberated. *Id.*, 129:5-131:15. Dr. Glew's incoherent and contradictory responses undermine his assertion that minority

[6] "So, there's a threshold voltage to turn on the transistor so that there is current flow from the source to gate." Ex.1063-Glew-Tr., 128:3-17, 107:13-17.

carriers must overcome opposing forces when drifting due to a static electric field is incorrect. Ex.2057, ¶50. His other arguments likewise fail.

*First*, Dr. Glew's assertion that carriers must overcome "the intrinsic resistance of silicon" before they move is incorrect. The carriers are *already in motion.* Ex.1060-Banerjee-Supp.-Decl., ¶¶17-19. "Intrinsic resistance" (or *resistivity*) is an inherent property of a material and its effect on carriers is analogous to a dampening force that may affect the *degree* of carrier mobility (i.e., the *speed* of carrier movement), but does not prevent carrier movement altogether. Ex.1060-Banerjee-Supp.-Decl., ¶¶36-41, 58-59. Thus, Greenthread's allegation of carrier "movement" being "prevented" by forces "cancel[ing] each other out" such that "carriers…do not move at all," POR 7-8, is technically meritless.

*Second*, Dr. Glew testified that "intrinsic resistance of silicon" in his declaration refers to resistance as employed in Ohm's Law, Ex.1063-Glew-Tr. 117:2-15, which hinges on physical dimensions. Ex.1060-Banerjee-Supp.-Decl., ¶39. Regardless, resistance (or resistivity) would affect the *ease* of movement (i.e., make carriers influenced by an electric field move slower), but cannot prevent the carriers from moving. *Id.*, ¶¶36-41, 58-59.

*Third*, pressed to identify what were the unexplained "other forces" mentioned in his declaration, Dr. Glew referred to stress in the silicon lattice. Ex.1063-Glew-Tr. 151:10-152:17, 157:21-158:5, 168:14-169:14. But Dr. Glew himself conceded

that stress would only impact resistance, *id.*, 159:15-160:2, which does not preclude carriers from moving. Ex.1060-Banerjee-Supp.-Decl., ¶¶43, 40-61.

*Fourth*—and most glaring, because Dr. Glew believes carriers will not move unless a threshold voltage is applied,[7] he admitted that he only analyzed whether "carrier movement" in prior art devices would occur *in the ON state*, while ignoring the *OFF* state. Ex.1063-Glew-Tr. 62:20-22 ("***I haven't performed an additional analysis of…any 'off' state activity***.").[8] He also admittedly had "not performed an analysis of…counterbalances of ***drift*** or of drift itself", *id.,* 63:13-15, even though the challenged claims pertain to movement due to drift and some even require a "drift layer." The devices in their ON state (*i.e.*, when an external voltage is applied) presents an entirely *different* scenario that was not raised by Greenthread when describing its invention during prosecution (*i.e.*, that the "built-in" electric field alone move carriers via drift). Ex.1060-Banerjee-Supp.-Decl., ¶¶49-51, 91-95. Dr. Glew's concession undermines his analysis on this term

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[7] "***When it is off, there is no movement of carriers***. Again, I've made this point a number of times." Ex.1063-Glew-Tr., 50:18-20.

[8] Dr. Glew's decision to ignore the *OFF* state may have stemmed from misconstruing "carrier movement" in the claims to mean *net movement of carriers*, i.e., net current. Ex.1063-Glew-Tr., 52:3-22, 62:10-22.

entirely, because, as Dr. Glew himself admitted, the claims are apparatus claims (*i.e.*, drawn to devices having structural features). Ex.1063-Glew-Tr., 207:7-209:14. Dr. Glew's failure to analyze *OFF*-state carrier movement, even when given the opportunity during deposition, *id.*, 50:10-62:22, warrants disregarding his analysis on this term altogether.

Tellingly, Dr. Glew admitted during deposition that he had only "glanced" at the prosecution history as ***"[i]t didn't seem relevant*** to…any of the issues I was rebutting at the time." Ex.1063-Glew-Tr., 179:18-180:6. He offered self-serving answers on the file history in response to questions from his attorney on redirect, but thereafter admitted he "[had]n't given…a lot of thought" to the fact that Greenthread was responding to a §112 rejection, *id.* 313:3-314:3.[9]

**5. Greenthread Mischaracterizes Mr. Warrick's Testimony**

Attempting to support its theory that the magnitude of the slope gradient dictates whether carriers move, Greenthread blatantly mischaracterizes the deposition of Scott Warrick, a Cirrus employee designated to testify on Cirrus's products.

[9] Dr. Banerjee breaks down Dr. Glew's technical inaccuracies in detail. *See* Ex.1060-Banerjee-Supp.-Decl., ¶¶57-104.

Greenthread highlights Warrick's reference to a "long list…of physical attributes, which affect the movement of carriers," POR 3, 7, but omits critical context: he was asked "[if] there's anything that affects the ***ease of*** carrier movement." Ex.2056, 71:22-72:8. Other factors, such as resistance, may affect the *speed* or *acceleration* of carrier movement (which even Greenthread admits is beyond the claim scope (Ex.1020, 38)), but Warrick never suggested they could overwhelm the drift field and preclude it from *aiding carrier movement* altogether. Warrick's statements are thus entirely consistent with Dr. Banerjee's analysis. Ex.1060-Banerjee-Supp.-Decl., ¶¶58-59.

Greenthread also isolated one page of a third-party teardown report to ask Warrick "if the gradient there would aid carrier movement downward?" Ex.2056, 93:8-95:3. But Greenthread never established where ***"there"*** was, or whether the ***direction*** of the gradient "there" was suited to aid movement "***downward,"*** let alone whether Warrick understood such to be the case. Warrick's puzzled response that he didn't "have an understanding" of what he was being shown, Ex.2056, 95:7-9, is thus hardly surprising.

#### 6. Greenthread Mischaracterizes *Markman* Orders from WDTX and EDTX

Greenthread also mischaracterizes the *Markman* orders from WDTX and EDTX. POR 9.

As to the WDTX Order, the Court was evaluating whether the term "graded" was indefinite and did not evaluate whether a minimum slope magnitude is needed to aid movement (a different issue that was not briefed). Greenthread cites the Court's assessment that "graded concentration has to be sufficiently graded," POR 9, but that does not imply that the *magnitude* of the slope matters. "*Sufficiently graded*" may refer to whether the graded concentration is sloped appropriately across the entire span specified by the claims—i.e., **"*from…to…*"**; for example, if the gradient's slope is in the right direction for only some segment(s) of that claimed span, but in the wrong direction for other segment(s), that may be *insufficiently* graded to satisfy the claims. *See* Ex.1060-Banerjee-Supp.-Decl., ¶23. Greenthread's suggestion that "sufficiently graded" refers to some threshold *magnitude*, POR 9, is belied by the Examiner's assessment (which Greenthread did not dispute) that "***any magnitude*** of the drift electric field, ***however small, reads on the claim***." Ex.1016, 139-40.

As to the EDTX Order, the Court was addressing whether a unidirectionally-sloped graded concentration is *necessary* to create a unidirectional electric drift field. *See* Ex.2075, 15. That is a different inquiry from whether a graded concentration is *sufficient* to create a drift field, and in turn, *sufficient* to move carriers. Indeed, in the same page of the Order, the Court acknowledged that "the patentee cited Grove to support that a graded dopant concentration ***will provide a unidirectional electric***

***drift field to move the minority carriers*** in a single direction." *Id.* Nothing in this Order suggests a threshold slope magnitude is needed to aid carrier movement.

### B. Greenthread's Claim Construction Arguments Fail

Compounding its technical inaccuracies, Greenthread seeks to rewrite the claims to avoid invalidity. Greenthread contends "'aid carrier movement' ***requires that a carrier move*** in the specified direction." POR 6, 8. That construction is wrong.

The challenged claims are drawn to *devices*, not *methods*. As such, they "cover what a device *is*, not what a device *does*." *ParkerVision, Inc. v. Qualcomm Inc.*, 903 F.3d 1354, 1361 (Fed. Cir. 2018). Here, the structural feature that the claimed device must include is clear: a "*graded dopant concentration* ***to*** aid carrier movement from the first surface to the second surface of the substrate." This is not an "improper collapsing of the terms." POR 6. This is an example of a limitation that, according the Federal Circuit, "recites '*capability*, as opposed to actual operation,'" such that the limitation is met by "an apparatus that is '*reasonably capable'* of performing the claimed function[]." *ParkerVision*, 903 F.3d at 1362 (citation omitted). As to the claimed devices here, a device having a "graded dopant concentration" sloped in a particular direction *has* the required capability (*i.e.*, "to aid carrier movement"), for all of the reasons discussed above. *See* §II.A; *see also ParkerVision*, 903 F.3d at 1361 (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.”).

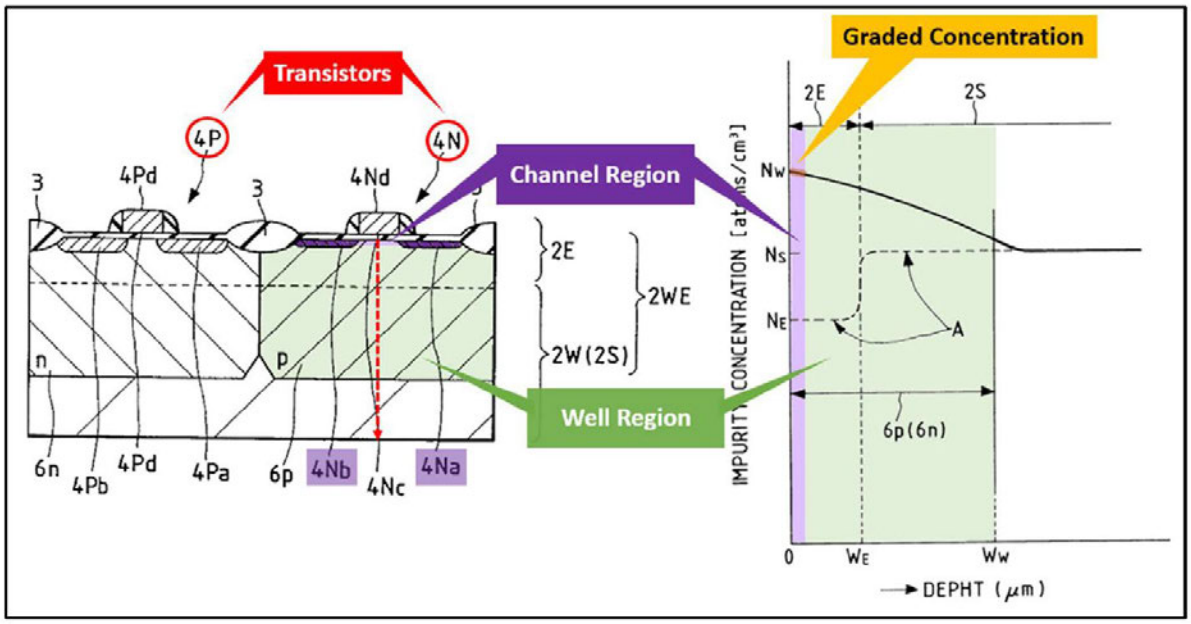
Further, Greenthread’s suggestion that “[t]he ‘probability or possibility’” of “movement ‘is insufficient,” POR 2, is a red herring that stems from its flawed construction, which miscasts the structural feature as a method step. The cited references disclose a graded dopant concentration sloped in a particular direction. A natural result of that structural feature is a built-in electric field that causes carriers to move via drift. Greenthread’s appeal to “*external*” factors, Ex.2057, ¶50, is ultimately unavailing, because such factors cannot undermine that natural result. *See Enzo Life Scis., Inc. v. Becton, Dickinson & Co.*, 780 F. App’x 903, 908 (Fed. Cir. 2019) (“A reference includes an inherent characteristic if that characteristic is the ‘natural result’ flowing from the reference’s explicitly explicated limitations, and “inherency cannot be defeated by interfering with th[at] natural result.”) (cit. omitted).

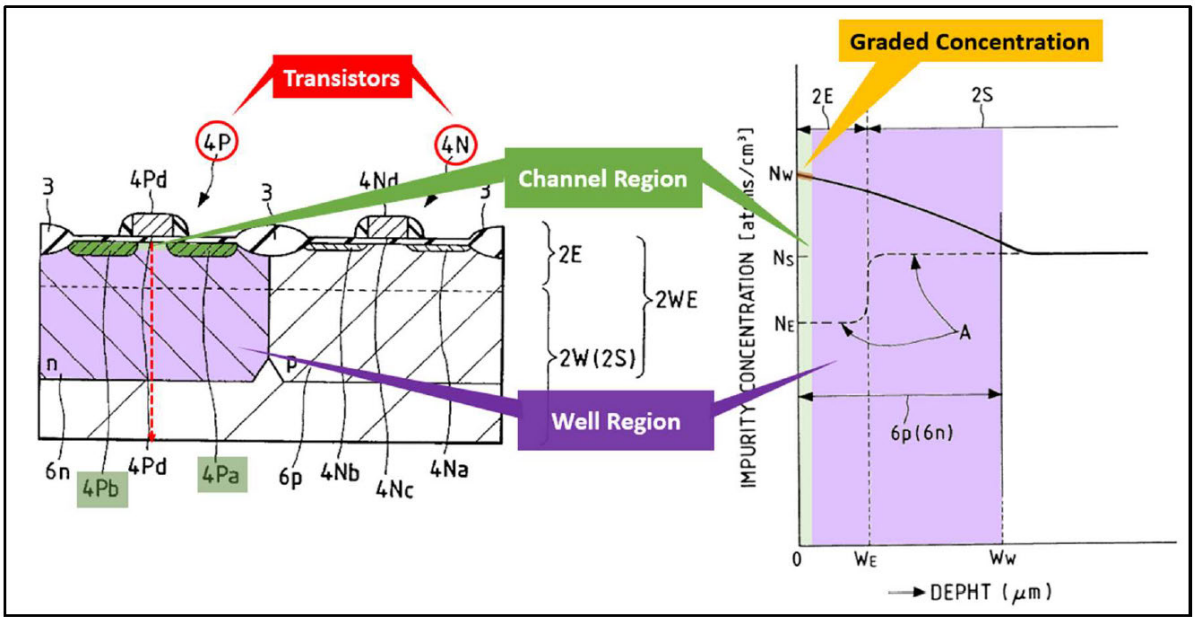
## III. THE CITED REFERENCES RENDER THE CHALLENGED CLAIMS OBVIOUS

### A. Kawagoe Discloses a “Graded Dopant Concentration to Aid Carrier Movement”

#### 1. Kawagoe’s Device Includes the Claimed Feature

As Petitioner explained, Kawagoe’s device features, in both the NMOS (4N) and the PMOS (4P), a downward-sloping gradient spanning “from the first surface to the second surface of the substrate.”




Pet. 28-39.

NMOS 4N formed in p-well *6p* has a graded concentration of *p*-type dopants, and the resulting ***built-in*** electric field moves minority carrier electrons from the "first surface to the second surface." Ex.1007, Figs. 17, 23. Similarly, PMOS 4P formed in n-well *6n* has a graded concentration of *n*-type dopants, and

the resulting ***built-in*** electric field moves minority carrier holes from the first surface to the second surface. Ex.1007, Figs. 17, 23. Dr. Glew admitted that Kawagoe has a downward-sloping gradient, and that well 6*p* and 6*n* will have carriers, Ex.1063-Glew-Tr., 237:3-242:15, but disagreed that the gradient would move the carriers. *Id.*, 245:2-5 ("if the charged particles are not free to move, then they just stay where they are with a force acting on them.").

For the reasons explained in §II.A above, Dr. Glew's position lacks merit, and Kawagoe discloses a "graded dopant concentration to aid carrier movement from the first surface to the second surface" (Elements 1.5 and 1.6).

#### 2. Kawagoe's Discussion on Alpha-Ray Strikes is Consistent with Aiding Carrier Movement in the Claimed Direction

Greenthread appeals to Kawagoe's discussion on the effects of alpha-ray strikes, POR 15-21, but that is unavailing.

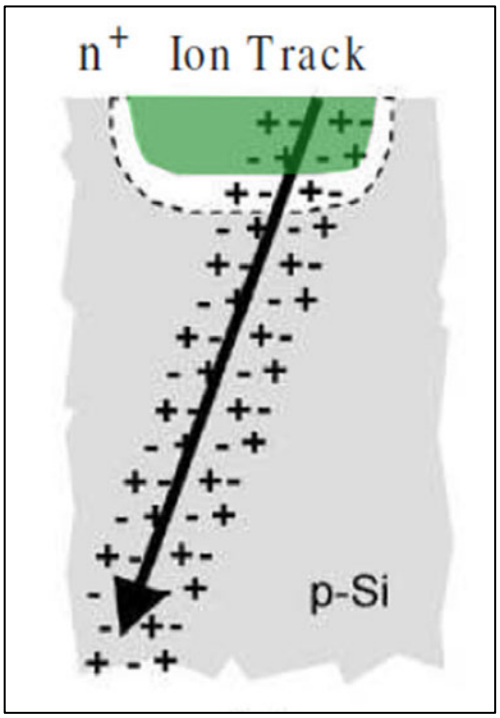
Greenthread fixates on Kawagoe's statement that electrons are "prevented from entering the p-well," POR 15-16, but that statement *supports* Petitioner's analysis. There, Kawagoe explains that its concentration gradient prevents electrons found *below* the well from moving upwards, which is the result of the same electric field that aids downward movement of the electrons in the well. As to the *claimed* direction—"from the first surface to the second surface of the substrate"—Kawagoe teaches that electrons are "attracted to the substrate body 2S by that concentration gradient," Pet. 31-32, lending further support to Petitioner's analysis. In other words,

aiding downwards is consistent with inhibiting movement in the opposite direction. As the Panel observed in a parallel proceeding, "the fact that carriers are prevented from entering the active regions in Kawagoe…appears to be strong evidence that the downward facing electric field is not negated or reversed by other fields or forces." *Semiconductor Components Industries*, *LLC v. Greenthread, LLC*, IPR2024-00263, Paper 23 at 19 (P.T.A.B. Aug. 5, 2004). This undermines Greenthread's speculation that "[o]ther forces…may…push [carriers] in the opposite direction from the force exerted by the gradient," POR 7, and that Kawagoe's concentration gradient would prevent carriers "located above" from entering well region 6p below, *id.*, 17, n.4. Since Kawagoe's gradient is consistently decreasing "from the first surface to the second surface of the substrate," the resulting electric field induces minority carrier drift *above and below* well region 6p.

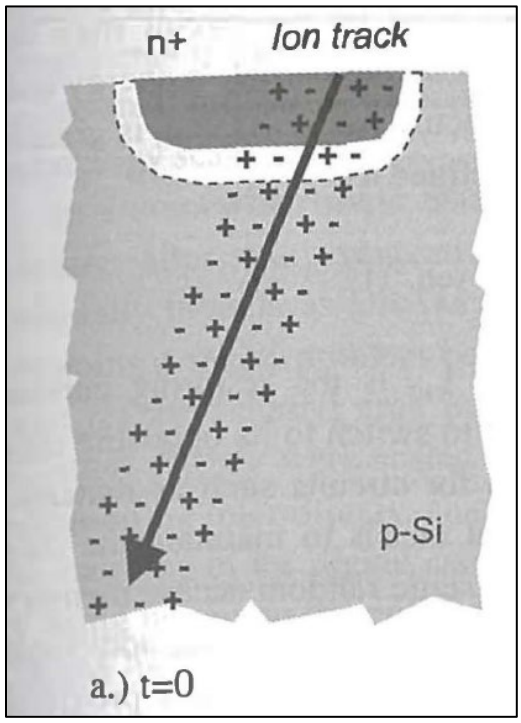
Greenthread argument that "Kawagoe's carriers are not in the active region," POR 16-17, is also baseless. Elsewhere, Greenthread *itself* admits that "Kawagoe's transistors presumably have carriers in the active region." POR 1-2. Dr. Glew likewise agreed that electrons would be present throughout Kawagoe's devices. Ex.1069-Glew-Tr.-OnSemi, 116:4-123:15, 120:16. Greenthread's "carriers in the wrong place" argument fails for this reason alone.

Further, contrary to Greenthread's arguments, the evidence makes clear that alpha-ray strikes create carriers in the active region. The 2008 Wang reference shows

and describes this. Ex.1009, 431. Greenthread dismisses Wang as not indicative of a POSITA's understanding as of the 2004 priority date, POR 18, but fails to appreciate that Wang cites an earlier 2004 article, Baumann (Ex.1065), containing *the same figure* relied upon by Petitioners, showing carriers in the active region:




Pet. 32-33; Ex.1009, 431




Ex.1065, 301

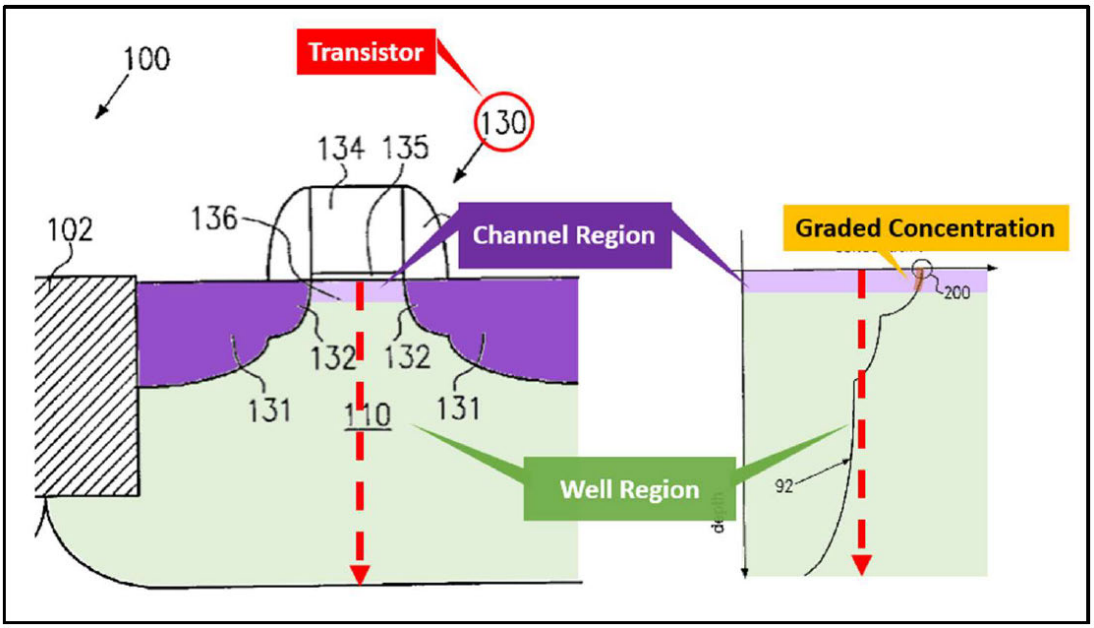
Further, Greenthread's arguments about whether Wang "give[s] a POSITA a reason to use Kawagoe in the active region," POR 18, are pointless; Petitioner is ***not*** proposing to modify Kawagoe in view of Wang.

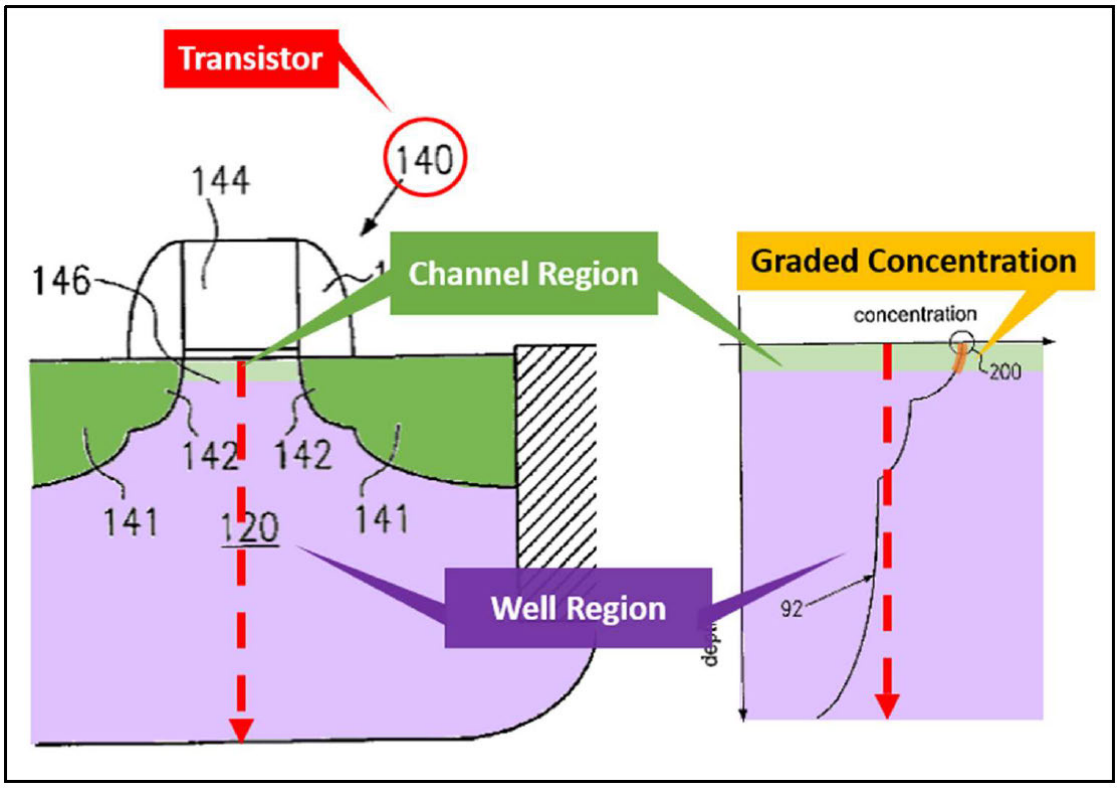
Finally, Greenthread's reliance on Nishizawa, POR 19, also fails. Nishizawa expressly states that, following an alpha-ray strike, "*several ten thousand electrons*

*will flow* into the n+ type region 13," which is part of the active region. Ex.2060, 19:41-42, Figs. 34-36.

### B. Wieczorek Discloses a "Graded Dopant Concentration to Aid Carrier Movement"

As Petitioner explained, Wieczorek's device features, in both the NMOS (130) and PMOS (140), a downward-sloping gradient spanning "from the first surface to the second surface of the substrate."






Pet. 63-68.

NMOS 130 formed in P-well 110 has a graded concentration of *p*-type dopants, and the resulting **built-in** electric field moves minority carrier electrons "from the first surface to the second surface." Ex.1006, Figs. 1b, 2b. Similarly, PMOS 140 formed in N-well 120 has a graded concentration of *n*-type dopants, and the resulting **built-in** electric field moves minority carrier holes "from the first surface to the second surface." Ex.1006, Figs. 1b, 2b.

For the reasons explained in §II.A above, that feature is a "graded dopant concentration to aid carrier movement" (Elements 1.5 and 1.6).

### C. Kawagoe Discloses a "First Active Region…With a Second [Opposite] Doping Type"

Greenthread alleges that the "first active region" identified by Petitioners in Kawagoe (an NMOS) does not have a "second doping type" opposite in conductivity to the "first doping type" in Kawagoe's substrate (i.e., *p-type*). POR 23-24. Greenthread points out that "the channel of transistor 4N is doped *p-type*," and (for that reason) concludes that Kawagoe lacks the claimed feature. *Id*., 23. That is wrong for multiple reasons.

*First*, Greenthread's argument incorrectly presumes that the claims require the "second doping type" to be distributed *throughout the entirety* of the identified "first active region." That assumption defies the plain language of the claims, which simply call for "a first active region…*with* a second doping type." Ex.1001, cls. 1, 20. It is sufficient that *some portions* of the "first active region"—here, the source and drain of Kawagoe's NMOS (4N) formed in p-well 6p—include a "second doping type" (*e.g.*, n-type dopants). Greenthread concedes this. POR 23 (Kawagoe's "regions 4Na and 4Nb are doped n-type."). Similarly, Figures 5B and 5C—which Greenthread says "clearly disclose[]" the "claimed invention" (POR 4; Ex.2057, ¶34)—show NMOS devices having n-type source and drain regions and a p-type substrate. Ex.1001, Figs. 5B-5C; Ex.1060-Banerjee-Supp.-Decl., ¶¶99-100.

*Second*, even assuming the claim were read to require "second doping type" dopants to be distributed throughout the "first active region" (*i.e.*, not just in the

source/drain, but also in the region where the channel is formed), that feature is still met by Kawagoe's PMOS (4P). As shown and described in Fig. 23, 4P is formed into an *n*-well, which contains *n*-type dopants *throughout* the well. Pet. 30-31; Ex.1007, 9:40-54, 17:50-54, 18:15-23, 21:55-61, Fig. 23. When the source and drain regions are subsequently formed, those *n*-type dopants remain present. Accordingly, even under Greenthread's unsupported construction, the source, drain, and channel region of Kawagoe's PMOS (4P) qualify as a "first active region" having a "second doping type" (*n*-type). Ex.1060-Banerjee-Supp.-Decl., ¶101.

### D. Kawagoe Alone or In View of Gupta Satisfies the Claimed "Isolation Region"

For dependent claims 6 and 26, Greenthread's argument that Kawagoe fails to disclose that the "first" and "second active region[s] are each separated by at least one ***isolation region***," POR 25-26, likewise hinges on unsupported claim construction and misreading Kawagoe.

Greenthread does not appear to dispute that Kawagoe's region 3 is an "isolation region." Instead, Greenthread incorrectly presumes that the claimed "isolation region" must achieve *physical separation along the entire depth* of the respective "first" and "second active region[s]." Not so. Under the plain language of the claims, Kawagoe's description and depiction of Figure 23's region 3 as an "*insulating film*" formed between the NMOS and PMOS transistors, Ex.1007, 8:40-52, discloses an "isolation region" that physically separates the first and

second active regions, regardless of its comparative physical dimensions. Further, while Kawagoe contemplates examples where active regions are "formed in the range of the thickness of the epitaxial layer 2E," Kawagoe also teaches such active regions having a depth significantly less than that of epitaxial layer 2E—*e.g.*, active regions 0.5μm deep versus epitaxial layer 5μm deep. Ex.1007, 8:36-40, 9:3-6, 9:47-53, 17:22-25. Ex.1060-Banerjee-Supp.-Decl., ¶¶102-103.

Regardless, Greenthread's focus on the physical dimensions of insulating film 3 is ultimately unavailing. Kawagoe states that a "channel stopper region is formed *below* the field insulating film 3, although not shown" in Figure 23. Pet. 41; Ex.1007, 8:43-45. As disclosed in Figure 26A, Kawagoe's "channel stoppers…16a and 16b" extend below the active regions. Ex.1007, 20:53-56, Fig. 26A. Dr. Glew admitted that the purpose of the channel stopper region "is to stop errant carriers from migrating from one transistor to another" and "[i]t needs to be deep enough to do that." Ex.1069-Glew-OnSemi-Tr., 142:4-143:11. Thus, in Figure 23, the insulating film 3 and channel stopper region are collectively the claimed "isolation region," even under Greenthread's construction. Ex.1060-Banerjee-Supp.-Decl., ¶¶52, 104.

## IV. GREENTHREAD'S LICENSE AGREEMENTS DO NOT SHOW NONOBVIOUSNESS

Greenthread's purported secondary considerations of non-obviousness should be rejected, because there is no evidence of industry praise or commercial

success, let alone a nexus of such factors to the challenged claims. Greenthread relies solely on the payment of licensing fees to support its secondary considerations, through the declaration of Dr. Rao (Ex.2072). That declaration should be disregarded. Dr. Rao conceded that his attorneys drafted the declaration, and he had no personal knowledge of the licenses that formed the basis of his declaration. Ex.1066-Rao-Tr. 21:2-8; 23:5-24:2; 44:15-18.

Regardless, "the fact that a patent has been licensed, taken alone, generally is insufficient for purposes of showing commercial success." *Intron Networked Sols., Inc. v. Acoustic Tech., Inc.*, No. IPR20170-01031, 2018 WL 10440326, at *10 (P.T.A.B. Aug. 21, 2018). Instead, for a license agreement to support non-obviousness, Federal Circuit precedent "specifically require affirmative evidence of nexus…because it is 'often cheaper to take licenses than to defend infringement suits.'" *Iron Grip Barbell Co. v. USA Sports, Inc.*, 392 F.3d 1317, 1324 (Fed. Cir. 2004) (cit. omitted). This wholly undermines Greenthread's reliance on licenses with [redacted]—which were settlements of Greenthread's active infringement lawsuits filed by Greenthread. Greenthread heaps reliance on a *Fox Factory* decision that was later vacated. *See Fox Factory, Inc. v. SRAM, LLC*, 944 F.3d 1366, 1378 (Fed. Cir. 2019). On remand, the Board ultimately found all challenged claims unpatentable, concluding that "at best, Patent Owner shows a *weak nexus*" for licenses

mentioning the challenged patent and "*no nexus* with respect to the remaining licenses" that did not. *Fox Factory, Inc. v. SRAM, LLC*, IPR2017-00472, Paper 74, 11, 14-15 (P.T.A.B. Feb. 25, 2021).

Further, as to all licensees, Greenthread lacks affirmative evidence that the license agreements were motivated by the technical merits of the challenged claims. Dr. Rao admittedly had no direct conversations with any licensees. Ex.1066-Rao-Tr., 23:5-24:2, and that the licenses included other patents that Greenthread did not assert during litigation, *id.*, 39:6-13.

Indeed, RPX explicitly markets itself as a cost-saving service that "spread[s] the cost of reducing patent litigation across a large network of

participating companies" and "remove[s] patents from circulation before they become costly issues." Ex.1067. [redacted]

## V. THE PETITION IS TIMELY UNDER 35 U.S.C. §315(B)

Greenthread parrots the same privity arguments that the Board and Director already considered, but rejected. Greenthread's POR arguments on privity appear to rely on the same set of facts and case law as its previous briefing on the issue. *See generally* Paper 15 (POPR); D.I. 11-23. Greenthread's rehashed timeliness challenge warrants no further consideration.

To recap, Petitioner's standard manufacturer/customer relationship with alleged RPIs did not provide Petitioner with a "full and fair" opportunity to challenge the validity of any patents in any previous matter. Petitioner was a stranger to the prior litigations of those alleged RPIs, and it would be unjust and contrary to precedent to bind Petitioner as a privy to those cases. *Taylor v. Sturgell*, 553 U.S. 880, 893-95 (2008); *WesternGeco LLC v. Ion Geophysical Corp.*, 889 F.3d 1308, 1319-22 (Fed. Cir. 2018).

Respectfully submitted,

Dated: November 8, 2024

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## CERTIFICATION OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24(d), I certify that the foregoing complies with the type-volume limitation of 37 C.F.R. § 42.24 and contains 5588 words based on the word count indicated by the word-processing system used to prepare the paper, and excluding those portions exempted by § 42.24(a).

Date: November 8, 2024

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## CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. § 42.6, I hereby certify that on the date listed below, a copy of Petitioner's Reply to Patent Owner's Response was served on the Patent Owner by electronic mail to the following counsel of record for Patent Owner:

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