

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

**INNOSCIENCE (ZHUHAI) TECHNOLOGY COMPANY, LTD.,
AND
INNOSCIENCE AMERICA, INC.,**

Petitioner, v.

EFFICIENT POWER CONVERSION CORPORATION,

Patent Owner.

**IPR2023-01381
U.S. Patent No. 8,350,294**

**Supplemental Declaration of E. Fred Schubert, Ph.D., in Support of Patent
Owner's Reply to Petitioner's Opposition to Patent Owner's Motion to
Amend**

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PATENT OWNER'S EXHIBIT LIST

Exhibit No.	Description
2001	Jorg Neugebauer et al., “Role of Hydrogen Complexes in Doping of GaN,” Material Research Society Symposium Proceedings, Vol. 423 (1996), pp. 619-24 (“Neugebauer-MRS1”)
2002	Jorg Neugebauer et al., “Theory of Point Defects and Complexes in GaN,” Material Research Society Symposium Proceedings, Vol. 395 (1996), pp. 645-56 (“Neugebauer-MRS2”)
2003	EPC’s Responsive Claim Construction Brief: Inv. No. 337-TA-1366, dated October 6, 2023
2004	IEEE Dictionary definition for “compensated”
2005	U.S. Patent No. 6,498,111 (“the ‘111 patent”)
2006	Translation of Innoscience’s Invalidation Request to the Chinese Patent Office for the Chinese Counterpart to the ‘294 Patent
2007	U.S. Patent App. No. 12/756, 906, filed on April 8, 2010
2008	U.S. Provisional App. No. 61/167,792, filed on April 8, 2009
2009	Declaration of Dr. E. Fred Schubert
2010	Respondents’ Post-Hearing Initial Brief (Inv. No. 337-TA-1366)
2011	Declaration of Dr. James Richard Shealy (IPR2023-01384)
2012	Deposition Transcript of Dr. Shealy (IPR2023-01381)
2013	Deposition Transcript of Dr. Shealy (IPR2023-01382, -01384)
2014	Evidentiary Hearing Transcript, pages 1-238 (Inv. No. 337-TA-1366) (Public)
2015	Evidentiary Hearing Transcript, pages 239-506 (Inv. No. 337-TA-1366) (Public)
2016	Evidentiary Hearing Transcript, pages 741-984 (Inv. No. 337-TA-1366) (Public)
2017	Evidentiary Hearing Transcript, pages 985-1270 (Inv. No. 337-TA-1366) (Public)

2018	Certified Translation of Innoscience’s Invalidation Request to the Chinese Patent Office for the Chinese Counterpart to the ‘294 Patent
2019	Certified Translation of Decision on Innoscience’s Invalidation Request to the Chinese Patent Office for the Chinese Counterpart to the ‘294 Patent
2020	“About Efficient Power Conversion Corporation,” https://epc-co.com/epc/about-epc , printed Mar. 2, 2023
2021	“SEMI Awards Honors Process and Technology Integration Achievements,” https://www.semi.org/en/semi-awards-honor-process-and-technology-integration-achievements , Jan. 13, 2016
2022	Public Initial Determination
2023	Complainant’s Responsive Post-Hearing Brief
2024	Supplemental Declaration of E. Fred Schubert, PhD., in Support of Patent Owner’s Reply to Petitioner’s Opposition to Patent Owner’s Motion to Amend
2025	Pre-Hearing Brief of the Commission Investigative Staff (Inv. No. 337-TA-1366) (Public)
2026	1999-Pankove-(MSE)- “GaN from fundamentals to applications”
2027	1998-Obloh-(JCG)- “Self-compensation in Mg doped p-type GaN grown by MOCVD”
2028	1999-Neugebauer-(SCSM)- “Theory of Hydrogen in GaN”

I, E. FRED SCHUBERT, PH.D., DECLARE AS FOLLOWS:

I. INTRODUCTION

1. My full name is Eric Fred Schubert, Ph.D., and I have been retained as a technical expert by Blank Rome LLP, counsel for Patent Owner Efficient Power Conversion Corporation (“Patent Owner” or “EPC”) to provide expert opinions with respect to claims 1-5 (“the Challenged Claims”) of U.S. Patent 8,350,294 (the “’294 patent”) (Exhibit 1001) in connection with Inter Partes Review Proceeding No. IPR2023-01381 initiated by Petitioners Innoscience (Zhuhai) Technology Company, Ltd., and Innoscience America, Inc. (collectively, “Innoscience” or “Petitioner”).

2. I submitted a first declaration in this matter in connection with EPC’s Patent Owner’s Response. My first declaration is marked as Ex. 2009. Since submitting my first declaration, Patent Owner filed a Motion to Amend, and the Petitioner filed an Opposition to the Motion to Amend.

3. I submit this supplemental declaration in support of Patent Owner’s Reply to Petitioner’s Opposition to the Motion to Amend. I incorporate by reference the analysis I provided in my first declaration in its entirety.

4. To the extent necessary, in addition to what is included in this declaration, I am prepared to testify to additional technical background as necessary and elaborate on the opinions and theories expressed herein.

II. LEGAL FRAMEWORK

5. In addition to the legal concepts I described in my first declaration, I understand that to be valid, claims must comply with a written description requirement. Under this requirement, a patent specification must describe in sufficient detail that a person of ordinary skill in the art would have reasonably concluded that the inventor possessed the claimed invention as of the effective filing date or date of invention. Possession means possession as shown in the disclosure and requires an objective inquiry into the four corners of the specification from the perspective of a person of ordinary skill in the art.

6. I understand that a claimed invention must be enabled. To be enabling, the specification of a patent must teach those skilled in the art how to make and use the full scope of the claimed invention without undue experimentation. Some experimentation, even a considerable amount, is not “undue” if it is merely routine, or if the specification provides a reasonable amount of guidance as to the direction in which experimentation should proceed.

7. I understand that factors to consider for enablement include: (1) the quantity of experimentation necessary, (2) the amount of direction or guidance presented, (3) the presence or absence of working examples, (4) the nature of the invention, (5) the state of the art, (6) the relative skill of those in the

art, (7) the predictability or unpredictability of the art, and (8) the breadth of the claims.

III. LEVEL OF ORDINARY SKILL IN THE ART

8. The opinions I set forth herein are through the eyes of the POSITA I defined in my first declaration.

9. Although I do not completely agree with Dr. Shealy's proposed POSITA, the differences between his proposed POSITA and my proposed POSITA would not affect any of my opinions disclosed herein or the outcome of this proceeding in any material manner.

IV. THE AMENDMENTS DO NOT LACK WRITTEN DESCRIPTION SUPPORT

10. Petitioner argues that there is no written description support for a "semi-insulating III-N layer [that] comprises a compensated GaN layer containing acceptor type dopant atoms passivated with hydrogen." Opposition to Motion to Amend (Paper 27) at 2-7. Specifically, Petitioner posits that the '294 patent never specifically describes a "semi-insulating III-N layer" that "comprises a compensated GaN layer." *Id.* at 3. Petitioner notes that, instead, the '294 patent describes separate embodiments for a compensated GaN layer (38) and a semi-insulating layer (39), and those layers are always described as being different layers made in different ways. *Id.* at 3-7. Due to these purported differences, the Petitioner concludes that no written description support exists. *Id.* at 7.

The separate embodiments noted by Petitioner, however, do not preclude written description support for a “semi-insulating III-N layer [that] comprises a compensated GaN layer containing acceptor type dopant atoms passivated with hydrogen.

11. The specification is clear that the described compensated GaN layer is a “highly compensated **semi-insulating** material” (emphasis added). EX1001, 3:43-51. The specification also indicates that “the insulating nature of compensated layer 38 reduces the gate capacitance of the device.” *Id.* at 3:19-21. A POSITA would thus understand that the compensated layer itself is semi-insulating and would recognize that a compensated GaN layer is a semi-insulating III-N layer.

12. The term “semi-insulating” is a term that characterizes the resistivity of a material. EX2018 at 17. Whereas a “compensated” layer is a term that characterizes the interaction of dopants in a layer. There is no mutual exclusion. A “compensated” layer can be semi-insulating. Indeed, Petitioner in its opposition admits that the compensated GaN layer has the electrical property of being semi-insulating. Paper 27 at 8. Moreover, although Petitioner now argues that the ’294 patent distinguishes “layer” from “material,” in its invalidation request before the CNIPA regarding the Chinese counterpart to the ’294 patent, Petitioner equates compensated semiconductor layer 38 to a “highly compensated semi-insulating GaN **layer**” (emphasis added) (“According to the evidence provided by the

Petitioner...a highly compensated semi-insulating GaN layer can be attained without the need for an additional annealing process...That is, the compensated semiconductor 38...can satisfy the requirements of the preferred embodiment...”) EX2018 at 21. Petitioner’s characterization of the compensated GaN layer in the China proceeding demonstrates that Petitioner agrees that a compensated GaN layer in the ’294 patent is a semi-insulating layer.

13. Petitioner’s treatment of the compensated GaN layer in the related ITC action is also informative. There, Petitioner indicated that the “parties agree that a ‘compensated GaN’ is passivated and a nonconductive or semi-insulating p-type GaN.” EX2010 at 32. It is thus clear that Petitioner believes that a compensated GaN layer is a semi-insulating layer.

14. In the alternative embodiments of the ’294 patent, semi-insulating layer 39 is doped with deep level impurity atoms, for example, C, Fe, Mn, Cr, V, or Ni. EX1001, 3:57-59. The first embodiment (which is directed to a compensated GaN layer), provides clear guidance to a POSITA that a “semi-insulating” resistivity state can be attained by passivating p-type impurities, instead of using deep level impurity atoms. EX1001, 3:43-52. That is, a semi-insulating layer in the ’294 patent is not limited to a layer with deep level impurity atoms.

15. I consider the term “semi-insulating” to be a term that characterizes the electrical conductivity (or resistivity) of a semiconductor material. In general,

semiconductors (such as GaN, GaAs, or Si) are not as insulating as insulators (such as SiO₂ and Si₃N₄). For this reason, the term “semi-insulating” is commonly used in conjunction with semiconductors (such as GaN and GaAs), whereas the term “insulating” is used in conjunction with insulators (such as SiO₂ and Si₃N₄).

16. The terms “material” and “layer” describe different physical objects. A “material” refers to the chemical or physical composition of matter. A “layer” refers to the geometrical shape of a material (a constant-thickness material may be referred to as a “layer”). Furthermore, a “layer” is generally made of a “material.” Similarly, a “material” can be shaped into a “layer.” If a “material” forming a “layer” is a semi-insulating material, the “layer” is semi-insulating as well. As a consequence, an insulating material cannot form a conductive layer.

17. The claim term “semi-insulating” does not imply that a material is co-doped or necessarily includes a deep-level dopant (such as C, Fe, or Cr), as Petitioner appears to suggest. The semi-insulating nature of a semiconductor can be achieved in different ways: As a first example, passivating p-type GaN with hydrogen, renders the GaN semi-insulating (as had been known prior to the invention of the '294 patent). As a second example, doping GaN with a deep level impurity can render the GaN semi-insulating (as had been known prior to the invention of the '294 patent).

18. Claims 4 and 5 provide further support. For example, independent claim 4 recites a “semi insulating III-N layer.” Claim 5, which depends on claim 4, recites that the semi-insulating III-N layer contains deep acceptor type dopant atoms. A POSITA would understand that the “semi-insulating III-N layer” of claim 4 is something broader than and not limited to a layer that contains deep acceptor type atoms.¹ The semi-insulating nature of the layer can be accomplished in other ways (such as passivating acceptor type dopant atoms with hydrogen). EX1001, 3:43-52. Accordingly, use of the term “semi-insulating III-N layer” in claim 4 was not limited to cover only the alternative deep-level dopant embodiments. It also covers the “compensated GaN” embodiment, which indisputably discloses that the compensated GaN layer is made of a highly compensated **semi-insulating** material. EX1001, 3:43-52. Because the claim term “semi-insulating III-N layer” of proposed amended claim 13 does not require or connote the use of a deep-level dopant, a POSITA would understand that the use of the term “semi-insulating III-N layer” in claim 13 is not limited to embodiments that require deep acceptor type dopant atoms. Put differently, there is adequate written description support for the notion that the “semi-insulating III-N layer” in the amended claims “comprises a

¹ Claims 4 and 5 have been cancelled by the non-contingent motion to amend. New claim 13 replaces claim 4.

compensated GaN layer containing acceptor type dopant atoms passivated with hydrogen.”

V. THE AMENDMENTS DO NOT BROADEN THE CLAIMS

19. The proposed amendments do not impermissibly broaden “semi-insulating III-N layer” to include a “compensated GaN layer containing acceptor type dopant atoms passivated with hydrogen” for the same reasons they do not lack written description support. Furthermore, because a compensated p-type GaN layer passivated by hydrogen is a specific type of semi-insulating III-N layer, the amendments are narrowing, not broadening. The claim term “semi-insulating layer” describes a layer whose electrical resistivity is characterized as semi-insulating. This is consistent with the plain and ordinary meaning of the claim term. The claim term “semi-insulating layer,” by and in of itself, does not imply a requirement that the semi-insulating properties of the layer be attained by a specific method. Accordingly, limiting the claim term “semi-insulating layer” to certain methods that result in the semi-insulating character of the layer would be contrary to the plain and ordinary meaning of the claim term.

20. A POSITA, being aware of the '294 patent's teachings, would understand that there are multiple ways to attain a semi-insulating nature of a III-N layer. The ways include the passivation of a p-type GaN layer with hydrogen. The

ways also include the doping of a GaN layer with a deep impurity level such as C, Fe, Mn, Cr, V, or Ni.

VI. THE AMENDED CLAIMS ARE ENABLED

21. Petitioner argues that a POSITA would have faced undue experimentation to make and use an “enhancement mode” transistor that includes a “semi-insulating III-N layer [that] comprises a compensated GaN layer containing acceptor type dopant atoms passivated with hydrogen” and has “no two-dimensional electron gas (2DEG) [] below the gate at zero volts applied gate bias.” Paper 27 at 8-9. Petitioner is wrong.

22. Although repackaged by Petitioner in many different ways, the gist of Petitioner’s enablement argument is that doping and passivation have competing effects on the ability of the p-GaN layer to deplete the 2DEG. Paper 27 at 9-18. As a result, according to the Petitioner, for a given thickness and doping concentration, increased passivation reduces the “active acceptor concentration” and reduces the ability of the p-GaN layer to deplete the 2DEG. Paper 27 at 12. In other words, because acceptor dopants in the p-GaN layer are passivated, they allegedly cannot contribute to depleting the 2DEG. And it is therefore difficult to figure out how to create an enhancement mode transistor.

23. Petitioner, however, has a misunderstanding of the science involved. The energy gain of a Mg acceptor accepting an electron from the conduction band

is 3.2 eV. EX2026 at 1; EX2027 at 1. The bandgap energy of GaN is 3.4 eV. EX2026 at 1. The Mg acceptor ionization energy in GaN is 0.2 eV. EX2027 at 1. The Mg acceptor level is located 0.2 eV above the valence band edge. EX2027 at 1. When an electron from the conduction band transitions to an acceptor atom, the electron falls from the conduction band to the Mg acceptor level, which is located 0.2 eV above the valence band edge. The energy gained is $E_g - E_a = 3.4 \text{ eV} - 200 \text{ meV} = 3.4 \text{ eV} - 0.2 \text{ eV} = 3.2 \text{ eV}$.

24. Conversely, the energy gain of a Mg acceptor binding a hydrogen atom (forming a bond to a hydrogen atom) is 1.5 eV. EX2028 at 14. Comparing these two energy gains reveals that it is energetically more favorable for an acceptor to accept an electron from the conduction band than to bind a hydrogen atom. A Mg atom thus would rather accept an electron from the conduction band (including the 2DEG) than a hydrogen atom.

25. Accordingly, the acceptors in the p-GaN layer in the inventive transistor disclosed by the '294 patent accept electrons from the 2DEG, thereby depleting the 2DEG and creating a normally-OFF (enhancement mode) transistor. EX2015, 378:15-17. To fulfill this function, the '294 patent discloses that the Mg doping needs to be sufficiently high ("the high doping level of compensated GaN layer 38 leads to enhancement mode devices"). EX1001, 3:16-17. A POSITA would understand from this disclosure that the Mg acceptor concentration should

have a high level of doping to deplete the 2DEG. For example, if the Mg acceptor concentration (per cm^2) is greater than the 2DEG electron density (per cm^2) the entire 2DEG under the gate can be depleted.

26. The disclosed “high doping level” of Mg acceptors in the p-GaN depletes the 2DEG, with excess Mg acceptors being passivated by hydrogen, so that none of the Mg acceptors generate free holes and the p-GaN becomes semi-insulating. EX2015, 378:15-17. As a result, undesirable gate leakage current through the bulk (not surface) of the p-GaN is substantially reduced. EX1001, 3:17-19. The gate capacitance is also reduced. EX1001:3:19-21. This follows the teaching of the ’294 patent: “the passivation of a p-type impurity using hydrogen...leads to...the compensated semiconductor layer 38 [being] a highly compensated semi-insulating material ...”EX1001, 3:43-52.

27. Because it is energetically more favorable for a Mg acceptor to accept an electron from the conduction band than to bind a hydrogen atom, the Mg acceptors in the p-GaN will preferentially deplete the 2DEG with remaining Mg acceptors being passivated by hydrogen. ’294 patent co-inventor Dr. Beach confirmed this operation during his trial testimony in the related ITC action (“Basically, the magnesium and the p-GaN will eat 2DEG electrons before getting passivated. It’s sort of an electron sponge.”). EX2015, 378:15-17.

28. As noted by the Board in its Preliminary Guidance on Patent Owner's Motion to Amend, some experimentation, even a considerable amount, is not "undue" if it is merely routine, or if the specification provides a reasonable amount of guidance as to the direction in which experimentation should proceed. Here, not only would any experimentation be routine, but also the specification provides sufficient guidance that is commensurate with the skills of a POSITA, and consistent with the guidance provided in US patents in general. A POSITA would appreciate the teachings of the '294 patent that the acceptor concentration needs to be sufficiently high to deplete the 2DEG. As a result, a POSITA would experimentally increase the p-type doping concentration until the 2DEG is depleted. Increasing the p-type doping concentration is a routine procedure that cannot be characterized as undue experimentation.

29. Petitioner argues that GaN layer thickness, doping, and passivation affect (1) whether a GaN layer is semi-insulating, and (2) whether 2DEG exists below the gate at zero volts applied gate bias. Paper 27 at 11-17. And, according to Petitioner, a POSITA would not have been able to identify the "narrow range" of GaN layer thickness, doping concentration, and passivation that meet the amended claims without undue experimentation. Paper 27 at 17. As a preliminary matter, the alleged "narrow range" does not exist. Instead, the acceptor doping must be sufficiently high to deplete the 2DEG with excess acceptors being

passivated by hydrogen thereby rendering the p-type GaN semi-insulating. Based on the '294 patent teachings that the level of doping needs to be sufficiently high, a POSITA would increase the doping concentration until the 2DEG is depleted. This, in my opinion, does not constitute undue experimentation. Furthermore, Petitioner's position is belied by Petitioner's obviousness arguments. Specifically, with respect to obviousness, Petitioner argues that a POSITA would have identified doping concentration, passivation level, and layer thickness that result in enhancement-mode transistors. This ability suggests routine, rather than undue experimentation.

30. The '294 patent provides adequate guidance as to the direction of experimentation to make its disclosure enabling. For example, the '294 patent discloses that the compensated semiconductive layer 38 has a "high doping level... lead[ing] to enhancement mode device" (EX1001, 3:16-17) where "the 2DEG region is depleted, i.e. removed, below the gate at zero applied gate bias" (EX1001, 1:47-50). As previously noted, a POSITA would understand from this disclosure that the Mg acceptor concentration must be sufficiently high to deplete the 2DEG. For example, the Mg density (per cm^2) must be greater than the 2DEG electron density (per cm^2) so that the entire 2DEG under the gate can be depleted. Increasing the doping concentration until the 2DEG depletes does not, in my opinion, constitute undue experimentation.

31. Regarding the passivation necessary to make a compensated GaN layer, the '294 patent discloses that “the critical step that differentiates the device of the present invention from the prior art device [] is the passivation of a p-type impurity using hydrogen.” EX1001, 3:43-45. Optionally, “an additional passivation can be performed by exposing the device to ammonia or hydrogen plasma at a high temperature.” EX1001, 3:37-39. The passivation results in a “highly compensated semi-insulating” layer with “low gate leakage during device operation” where “capacitance of the gate electrode to channel layer is reduced...as compared to the prior art.” EX1001, 3:46-52. Knowing these disclosed goals and using the disclosed guidance for achieving these goals, a POSITA could comfortably make and use the transistors of the amended claims.²

VII. THE AMENDED CLAIMS ARE NOT OBVIOUS

A. Petitioner’s Claim Constructions Are Not Necessary Or Incorrect

32. Petitioner offers two so-called claim “interpretations” for claim elements [13e.2] and [14c.2]. Paper 27 at 19-21. Petitioner’s “second interpretation” (“interpretation ii”) is an attempt to interpret the claims in a way that is inconsistent with the plain and ordinary meaning of the claim term “semi-

² I note that the CNIPA, in its Invalidation Decision regarding the Chinese counterpart to the '294 patent, agrees, finding that “[t]here are no contradictions or ambiguities. [Those] skilled in the art can implement the technical solution of the invention, solve its technical problems, and achieve the expected technical effects according to the content described in the description.” Ex. 2019 at 9.

insulating III-N layer.” The claim term “semi-insulating III-N layer” specifies a III-N layer that is electrically semi-insulating, and not a specific method (such as doping with deep level impurities) by which the “semi-insulating III-N layer” is produced. Petitioner’s apparent claim construction, that the semi-insulating III-N layer is doped with deep level impurity atoms, is directed to a configuration that is unsupported by the plain and ordinary meaning of the claim terms, specifically the plain and ordinary meaning of the claim term “semi-insulating III-N layer.” It would therefore be improper to limit the claims in that manner. I note that even if Petitioner’s constructions were to be correct, which they are not, the ultimate conclusion (that the ’294 patent claims are valid) does not depend on either of Petitioner’s “interpretations.” Under both interpretations, the asserted prior art fails to render the amended claims obvious, as discussed below.

B. Smith Does Not Disclose Or Render Obvious An “Enhancement Mode” Transistor “Wherein No Two Dimensional Gas (2DEG) Region Exists Below The Gate At Zero Volts Applied Gate Bias”

33. Petitioner argues that Smith discloses or renders obvious an enhancement mode transistor with no 2DEG below the gate at zero volts applied gate bias. Petitioner is wrong (under either of Petitioner’s proposed constructions) for at least the same reasons provided in my first declaration.³

³ It is worth noting that both the CNIPA and ITC OUII believe that Smith is directed to a depletion mode transistor, not an enhancement mode transistor. EX2019 at 11 (“D1 discloses a depletion mode transistor, and the doped region 40

34. In addition, Petitioner relies on opinions from its expert, Dr. Shealy, who suggests that Patent Owner's view that Smith is not directed to an enhancement mode transistor would be wholly dependent on a belief that the cap layer in FIG. 2A is in direct contact with both ohmic contacts. Paper 27 at 24, citing EX1033, [046]-[059]. That is not the case. Even if the cap layer of FIG. 2A was not in direct contact with both ohmic contacts, so that a small gap existed between the cap layer and the ohmic contacts, Smith still would not be fairly considered to be directed to an enhancement mode transistor. For example, even with a small gap between the cap layer and the ohmic contacts⁴ (if the transistor of FIG. 2A were set up to have no 2DEG below the gate at zero gate bias), when a positive voltage is applied to the gate, the 2DEG would only replenish generally directly beneath the gate electrode. Because the access regions are significantly wider than the small gaps between the cap layer and ohmic contacts, they would remain depleted of free electrons, and the transistor would be inoperable.

cannot deplete the two-dimensional electron gas. The role of the doped region 40 and the cap layer 34 is to screen the channel region from the surface states and pin the surface energy level at a predictable and desired level to reduce and/or minimize trapping effects."); EX2025 at 30.

⁴ As depicted in the below modified version of FIG. 2A that I prepared.

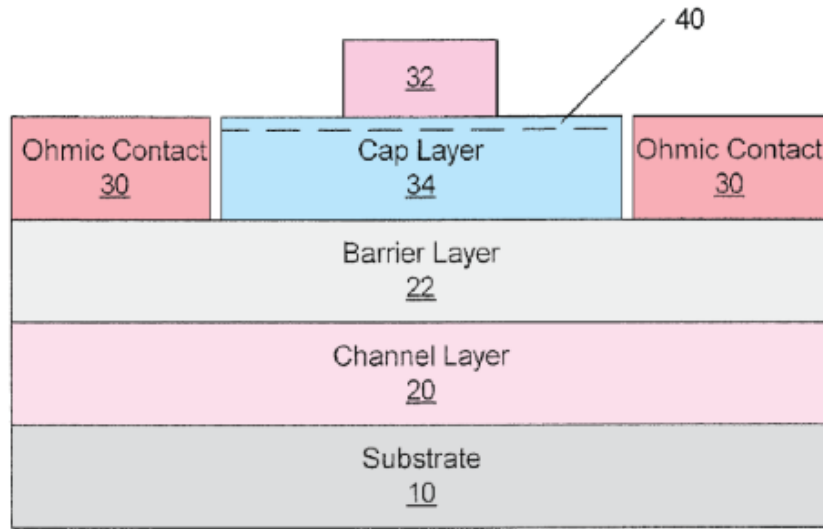


Figure 2A

35. Smith states the following:

The dopants at the outer surface of the device may segregate to dislocations in the cap layer and, thereby, reduce gate leakage along the dislocations. The dopant may have different characteristics when at a dislocation than when in the bulk crystal. For example, a shallow dopant in the bulk crystal may have characteristics of a deep level when at a dislocation. Thus, references to p-type, n-type or deep-level dopants refers to the characteristics of the dopants in the bulk crystal rather than at a dislocation. This may be especially true in the case of p-type or deep level dopants. EX1005 (“Smith”), [0064].

36. I note that the dopants associated with dislocations, as envisioned by Smith, have never been shown by Petitioner to be capable of depleting a 2DEG.

37. Moreover, as noted by the Board in its Preliminary Guidance on Patent Owner’s Motion to Amend, even though Petitioner’s expert identifies cap layer thickness and doping concentrations in Smith’s cap layer, Petitioner has

provided no evidence that acceptor-type dopants present in Smith's cap layer in fact cause the 2DEG beneath the gate to be depleted at zero volts applied gate bias. Preliminary Guidance (Paper 29) at 11. Accordingly, Petitioner has not shown that Smith discloses or obviates an enhancement mode transistor wherein no 2DEG region exists below the gate at zero volts applied gate bias.

38. Petitioner also argues that Smith renders this feature obvious. For example, Petitioner indicates that "[a] POSITA knew that hydrogen would have been naturally incorporated into the cap layer and passivated dopants, including region 400...A POSITA would have identified doping concentration and layer thickness that result in enhancement mode devices even with natural passivation given Smith's disclosures of ranges of these variables." Paper 27 at 31. That argument fails.

39. As a preliminary point, I note that Smith teaches MBE (molecular beam epitaxy) as an epitaxial growth technique for GaN ("Furthermore, the channel layer and/or buffer nucleation and/or transition layers may be deposited by [...] MBE ..." (Smith, [0073]). MBE does not employ hydrogen, so that there is no opportunity for "hydrogen [to be] naturally incorporated."

40. Furthermore, even though Smith discloses ranges of doping concentration and layer thickness, Petitioner does not adequately explain *why* these ranges would render it obvious for Smith to be implemented as an enhancement

mode transistor with no 2DEG below the gate at zero volts applied gate bias.

Petitioner argues that “a POSITA would have maintained an active dopant concentration that depleted the 2DEG” in order to “realize the benefits of enhancement mode devices, including reduced power consumption and suitability for high power applications.” Paper 27 at 32. But even if Smith’s transistor were modified so that no 2DEG exists below the gate at zero volts applied gate bias, it would still not work as an enhancement mode transistor (e.g., because the 2DEG would not be replenished enough to turn the transistor ON upon application of a positive gate voltage).

41. Petitioner’s expert theorizes that the 2DEG could conceivably exist if you put enough gate voltage on it. Ex. 2010 at 41-42; EX1033, [063]-[067]. But Petitioner’s experts do not have a quantitative basis for this theory and have neither modeled nor simulated it. Ex. 2016 at 938:19-939:8 (Lebby). Nevertheless, if such a device were to be created, Petitioner’s ITC expert confirmed that it “may not be an ideal device” and would have “lots of leakage” due to the massive amount of voltage passing through the gate. EX2016 at 939:5-8. These problems evidence a lack of motivation to modify Smith to be an enhancement mode transistor.

42. In this context, I also note that Petitioner’s expert, Dr. Shealy, in another USPTO IPR proceeding, disparaged a device structure he now contends

would obviate the enhancement mode transistor of the proposed amended claims of the '294 patent. Dr. Shealy characterized the specific transistor in question by using the words:⁵ “disaster,” “bad idea,” “it's not something you can fab,” and “the way it's described here, it would be in depletion mode.” ('347 & '335 Deposition Transcript of Dr. Shealy, IPR2023-01382 and IPR2023-01384, page 56, lines 16-18; page 62, 21-22; page 72, 13-15)

C. Smith Does Not Disclose Or Render Obvious That A “Semi-Insulating III-N Layer Comprises A Compensated GaN Layer Containing Acceptor Type Dopant Atoms Passivated With Hydrogen”

43. Smith does not disclose or render obvious that a “semi-insulating III-N layer comprises a compensated GaN layer containing acceptor type dopant atoms passivated with hydrogen” (under either of Petitioner’s proposed constructions), for at least the same reasons provided in my first declaration.

D. Neither Smith In View of Kigami Nor Smith In View of Uemoto Render Obvious An “Enhancement Mode” Transistor “Wherein No Two Dimensional Gas (2DEG) Region Exists Below The Gate At Zero Volts Applied Gate Bias”

44. Petitioner argues that Smith in view of Kigami and Smith in view of Uemoto both render obvious an enhancement mode transistor with no 2DEG below the gate at zero volts applied gate bias. Paper 27 at 31-32. Under either of

⁵ Dr. Shealy’s quoted deposition statements were made in conjunction with Figures 1B and 2A of Saxler-’606. Figures 1B and 2A of Saxler-’606 are identical to Figures 1B and 2A of Smith-’315.

Petitioner's proposed constructions ("interpretation i and ii"), Petitioner is incorrect for at least the same reasons provided in my first declaration.

45. In addition, Petitioner posits that "Kigami's and Uemoto's localized, controlled passivation in combination with Smith render obvious enhancement mode operation with no 2DEG below the gate at zero volts bias." Paper 27 at 32. Petitioner insists that "a POSITA would have maintained an active dopant concentration that depleted the 2DEG" in order to "realize the benefits of enhancement mode devices, including reduced power consumption and suitability for high power applications." Paper 27 at 32.

46. First, there is no teaching in either Kigami or Uemoto that would motivate a POSITA to modify Smith's depletion mode transistor to create an enhancement mode transistor with no 2DEG below the gate at zero volts bias. Recognizing this deficiency, Petitioner plucks a purported motivation from the Suh2006 article. Paper 27 at 32. Petitioner's use of this motivation appears to be based on hindsight.

47. Even if Smith's transistor were somehow modified by Kigami or Uemoto so that no 2DEG exists below the gate at zero volts applied gate bias, the resulting transistor would not work as an enhancement mode transistor, because the 2DEG would not be replenished enough to turn the transistor ON upon application of a positive gate voltage. Petitioner believes that by applying enough

voltage to the gate, that the resulting transistor could be made to operate as an enhancement mode transistor. But the problems that arise by forcing the 2DEG to allegedly exist by greatly increasing the voltage applied to the gate evidence a lack of motivation to modify Smith to become an enhancement mode transistor. *See* paragraph 41 (*supra*).

E. Neither Smith In View of Kigami Nor Smith In View of Uemoto Render Obvious That A “Semi-Insulating III-N Layer Comprises A Compensated GaN Layer Containing Acceptor Type Dopant Atoms Passivated With Hydrogen”

48. Neither Smith in view of Kigami nor Smith in view of Uemoto render obvious that a “semi-insulating III-N layer comprises a compensated GaN layer containing acceptor type dopant atoms passivated with hydrogen” (under either of Petitioner’s proposed constructions, “interpretation i and ii”), for at least the same reasons provided in my first declaration.

F. Sheu In View of Kigami Does Not Render Obvious An “Enhancement Mode” Transistor “Wherein No Two Dimensional Gas (2DEG) Region Exists Below The Gate At Zero Volts Applied Gate Bias”

49. Petitioner argues that a POSITA would have recognized that Sheu/Kigami results in enhancement mode operation because Sheu’s layer 318 is a p-doped cap layer below gate 316 and on top of barrier layer 310. Paper 27 at 38. Petitioner also urges that “it would accordingly have been obvious that Sheu’s transistor would operate as an enhancement-mode device because a POSITA knew this arrangement operated in enhancement mode long before the ’294 patent.”

Paper 27 at 38. Petitioner uses similar rationale for arguing that Sheu/Kigami renders obvious “no two-dimensional electron gas (2DEG) region [that] exists below the gate at zero volts applied gate bias.” Paper 27 at 45.

50. The teachings of Sheu, however, fly in the face of Petitioner’s positions. Sheu quite clearly discloses a depletion mode transistor. Accordingly, Petitioner’s premise that Sheu’s transistor would operate as an enhancement-mode device because a POSITA knew the arrangement of Sheu’s components operated in enhancement mode is incorrect. Instead, the disclosures of Sheu inform a POSITA that the disclosed arrangement of Sheu’s components results in a depletion mode transistor (which in turn means that the 2DEG exists below the gate at zero volts applied gate bias).

51. A POSITA would appreciate that Sheu discloses a depletion mode transistor, not an enhancement mode transistor. For example, FIG. 4 of Sheu, reproduced below, depicts the relationship between reverse gate voltage and gate leakage current in the transistors of FIGS. 1 and 3. EX1036 at 8. FIG. 4 shows that as the gate voltage gets more negative, gate leakage current increases. This relationship is consistent with a depletion mode transistor, which is “normally ON” and turns OFF when a negative voltage is applied to the gate.⁶

⁶ Petitioner may argue that it relies on the embodiment of FIG. 6, not FIG. 4 (Fig. 4 relates to the embodiments shown in Figs. 1 and 3). But the gate insulating layer 318 in FIG. 6 is the same as that which relates to FIG. 4. A POSITA would

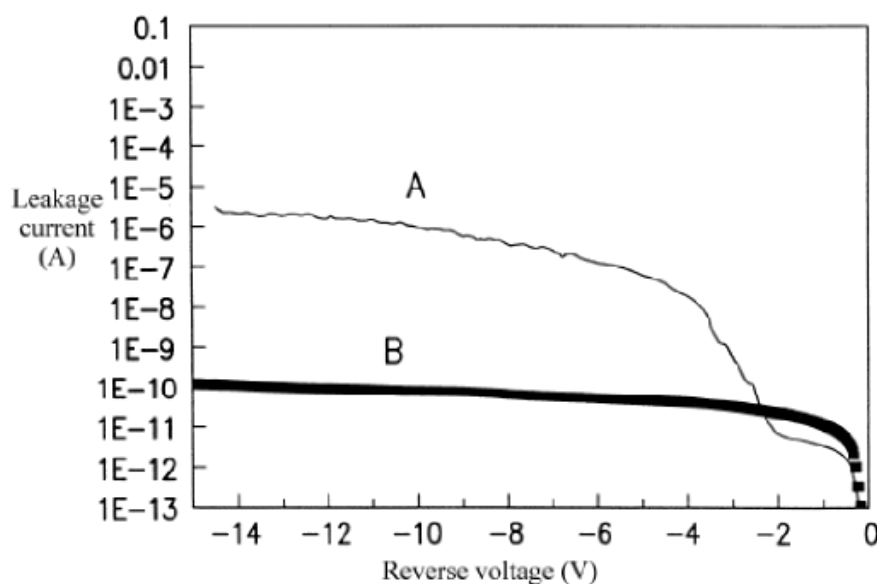


FIG. 4

52. Indeed, both OUII from the related ITC action and the CNIPA agree that Sheu is directed to just a depletion mode transistor. For example, in its pre-hearing brief, OUII argued that “Sheu discloses a depletion-mode field effect transistor.” EX2025 at 32. In addition, OUII noted that because enhancement mode and depletion mode transistors differ significantly in their design and operation, a POSITA would not have been motivated to combine features from one that would perform very differently in the other. EX2025 at 33. Similarly, the CNIPA, in its Invalidation Decision upholding the validity of the Chinese counterpart to the ’294 patent, wrote that the barrier layer 310 in Sheu is Si-doped

understand the relationship between reverse bias voltage and gate leakage current to be the same in both embodiments.

$\text{Al}_x\text{In}_y\text{Ga}_{1-x-y}\text{N}$ and its conductivity type is n-type, thus producing a depletion mode transistor. EX2019 at 13. The CNIPA also found that the role of the GaN-based gate insulating layer 318 in Sheu is to improve the lattice matching between the gate insulating layer and the GaN-based semiconductor layer, and the role of Mg doping in the GaN-based gate insulating layer is to enhance the resistance of the gate insulating layer 318. EX2019 at 13.

53. In view of Sheu's clear disclosures (see Sheu's Figure 4, and Sheu's Si-doped barrier layer) that are directed to a depletion mode transistor, not an enhancement mode transistor, Petitioner's obviousness arguments fall flat. Petitioner bases its arguments on the notion that a POSITA would understand that a p-doped cap layer below a gate electrode and on top of a barrier layer necessarily results in an enhancement mode transistor. But because Sheu discloses a depletion mode transistor (by means of its Figure 4 and Sheu's Si-doped barrier layer), the assumption that Sheu would operate as an enhancement mode transistor, on which Petitioner relies, is incorrect. Because Sheu alone, and Sheu in view of Kigami, do not result in an enhancement mode transistor, a POSITA could not possibly arrive at an enhancement mode transistor that has no 2DEG below the gate at zero volts applied gate bias.

G. Sheu In View of Kigami Does Not Render Obvious That A “Semi-Insulating III-N Layer Comprises A Compensated GaN Layer Containing Acceptor Type Dopant Atoms Passivated With Hydrogen”

54. Petitioner argues that when Sheu’s gate insulating layer 318 is doped with magnesium and subject to Kigami’s hydrogenation, the layer is a “compensated GaN layer.” Paper 27 at 41-44. As Petitioner seems to recognize, Sheu does not by itself disclose “a compensated GaN layer containing acceptor type dopant atoms passivated with hydrogen.” Instead, Petitioner combines Sheu with Kigami to attempt to provide this feature. Kigami, however, fails to cure Sheu’s deficiencies.

55. Sheu does not reference compensation or passivation with hydrogen at all, but rather states that one or more dopants (carbon, magnesium, and/or iron) may be used “to enhance the resistance value” of the GaN layer 318. EX1036 at 10. That is, it is the dopants themselves that enhance the resistance value, which a POSITA would understand to mean may increase the resistance value. The reason adding a p-type dopant, such as Mg, would increase the resistance is that the gate insulating layer may be originally n-type. Passivating those dopants with hydrogen would negate the purpose for which Sheu introduced dopants in its device and go against its own teachings. Accordingly, a POSITA would not be motivated to combine Sheu and Kigmai, under either of Petitioner’s claim constructions.

56. In addition, Kigami uses an entirely different gate layer structure, specifically a “gate insulating film” below the gate contact and incorporates a hydrogenated p-type GaN layer as the channel layer. EX1008, [020]-[022]; EX2012 at 21:4-23:20. Notably, neither Sheu alone nor Sheu in view of Kigami passivates Mg acceptors in the gate structure. Nothing in Kigami discloses or suggests that its hydrogen-treated p-type GaN channel layer would be suitable below the gate contact or that a compensated GaN layer including Mg dopants and hydrogen would be acceptable or functional in place of Sheu’s GaN-based gate insulating layer.

57. Moreover, Kigami teaches the passivation of the channel layer which has no effect on the layers above the 2DEG, specifically the layers located between the 2DEG and gate electrode. EX1008, [020]-[022]. Combining Sheu and Kigami would not arrive at the claimed invention. Sheu’s channel layer is undoped and Kigami passivates the channel layer. Using Kigami’s channel passivation technique in Sheu would serve no purpose and have no effect.

I, E. FRED SCHUBERT, DO HEREBY DECLARE AND STATE, THAT ALL STATEMENTS MADE HEREIN OF MY KNOWLEDGE ARE TRUE AND THAT ALL STATEMENTS MADE ON INFORMATION AND BELIEF ARE BELIEVED TO BE TRUE; AND FURTHER THAT THESE STATEMENTS WERE MADE WITH THE KNOWLEDGE THAT WILLFUL FALSE STATEMENTS AND THE LIKE SO MADE ARE PUNISHABLE BY FINE OR IMPRISONMENT, UNDER SECTION 1001 OF TITLE 18 OF THE UNITED STATES CODE AND MAY JEOPARDIZE THE VALIDITY OF THE APPLICATION OR ANY PATENT ISSUING THEREON.

Executed on: October 15, 2024

Location: Troy NY

By: 2024