

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 8,350,294

**PETITIONER'S OPPOSITION TO PATENT OWNER'S
MOTION TO AMEND**

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EXHIBIT LIST

Exhibit	Description
Ex. 1001	U.S. Patent No. 8,350,294 B2 (“the ’294 patent”)
Ex. 1002	Prosecution History of the ’294 patent (“ <i>Prosecution History</i> ”)
Ex. 1003	Declaration of Dr. James Richard Shealy (“ShealyPet”)
Ex. 1004	Curriculum Vitae of Dr. James Richard Shealy
Ex. 1005	U.S. Patent Application Publication No. US 2007/0164315 A1 to Smith (“ <i>Smith</i> ”)
Ex. 1006	U.S. Patent Application Publication No. US 2008/0087915 A1 to Uemoto (“ <i>Uemoto</i> ”)
Ex. 1007	Japanese Patent Publication No. JP2006-253224 A to Kigami.
Ex. 1008	Certified English Translation of Japanese Patent Publication No. JP2006-253224 A (“ <i>Kigami</i> ”)
Ex. 1009	Translator’s Declaration for Certified English Translation of JP 2006-253224 A.
Ex. 1010	Umesh K. Mishra et al., <i>AlGaIn/GaN HEMTs—An Overview of Device Operation and Applications</i> , Proceedings of the IEEE, vol. 90, no. 6 (June 2002), pp. 1022-1031 (“ <i>Mishra</i> ”).
Ex. 1011	Excerpts of Rüdiger Quay, <i>Gallium Nitride Electronics</i> , vol. 96, Springer Science & Business Media (2008) (“ <i>Quay</i> ”).
Ex. 1012	Excerpts of Stephen J. Pearton et al., <i>Gallium Nitride Processing for Electronics, Sensors and Spintronics</i> , Springer Science & Business Media (2006) (“ <i>Pearton</i> ”).
Ex. 1013	U.S. Patent Application Publication No. US 2004/0012015 A1 to Saxler (“ <i>Saxler015</i> ”)

Exhibit	Description
Ex. 1014	X. Hu et al., <i>Enhancement mode AlGaIn/GaN HFET with selectively grown pn junction gate</i> , Electronics Letters, vol. 36, no. 8 (2000), pp. 753-754 (“Hu”).
Ex. 1015	Excerpts of Chang Soo Suh, Enhancement-Mode GaN-Based HEMTs for High-Voltage Switching Applications (Dec. 2008) (Ph.D. dissertation, University of California, Santa Barbara) (“Suh”).
Ex. 1016	U.S. Patent Application Publication No. US 2005/0145874 A1 to Saxler (“Saxler874”)
Ex. 1017	Chris G. Van de Walle et al., “Hydrogen in III-V Nitrides,” <i>Semiconductors and Semimetals</i> , vol. 57 (1998), pp. 157-184 (“Van de Walle”).
Ex. 1018	Shuji Nakamura et al., <i>Hole Compensation Mechanism of P-Type GaN Films</i> ,” Japanese Journal of Applied Physics, vol. 31 (1992), pp. 1258-1266 (“Nakamura”).
Ex. 1019	Complainant’s Proposed Constructions & Respondents’ Proposed Constructions in related International Trade Commission investigation: <i>In the Matter of Certain Semiconductor Devices, and Methods of Manufacturing Same and Products Containing the Same</i> , Inv. No. 337-TA-1366, dated September 5, 2023 (“ITC Constructions”).
Ex. 1020	U.S. Patent No. 5,985,687 (“Bowers”)
Ex. 1021	U.S. Patent Application Publication No. 2002/0167023 A1 to Chavarkar (“Chavarkar”)
Ex. 1022	U.S. Patent Application Publication No. 2003/0102482 A1 to Saxler (“Saxler482”)
Ex. 1023	Shuji Nakamura – Biographical, NobelPrize.org, Nobel Prize Outreach AB 2023, www.nobelprize.org/prizes/physics/2014/nakamura/biographical/ (last visited Aug. 28, 2023) (“Biographical Nakamura”)

Exhibit	Description
Ex. 1024	Excerpts of Vasco Matias, Defect characterization of Europium implanted Gallium Nitride (2008) (Ph.D. dissertation, KU University, Belgium) (“ <i>Matias</i> ”).
Ex. 1025	Email exchange between Petitioner and Board, Board email dated January 9, 2024.
Ex. 1026	<i>Merriam-Webster Dictionary</i> (excerpt) (2022)
Ex. 1027	Prepositions of Place in English Grammar, LanGeek.co, Prepositions and Conjunctions, https://langeek.co/en/grammar/course/69/prepositions-of-place (last visited Jan. 15, 2024)
Ex. 1028	Transcript of Conference Call with the Board, taken on August 6, 2024
Ex. 1029	Email exchange between Petitioner and Patent Owner, Petitioner email dated August 7, 2024.
Ex. 1030	Email exchange between Petitioner and Board, Board email dated August 8, 2024.
Ex. 1031	Exhibit 28 to Verified Complaint in International Trade Commission <i>Certain Semiconductor Devices, And methods Of Manufacturing Same And Products Containing the Same</i> . Inv. No. 337-TA-1366.
Ex. 1032	Exhibit RX-0255 in Inv. No. 337-TA-1366. Book: E. Fred Schubert. Doping in III-V semiconductors. AT&T Bell Laboratories, New Jersey. (1993)
Ex. 1033	Supplemental Reply Declaration of Dr. James Richard Shealy, Dated September 3, 2024 (“ <i>ShealyReply</i> ”).
Ex. 1034	Excerpts of Revised and Corrected Transcript, Open Sessions, Inv. No. 337-TA-1366
Ex. 1035	Taiwanese Patent Publication No. TW200414540 A to Sheu.

Exhibit	Description
Ex. 1036	Certified English Translation of Taiwanese Patent Office Publication No. TW200414540A (“ <i>Sheu</i> ”)
Ex. 1037	Translator’s Declaration for Certified English Translation of TW200414540A.
Ex. 1038	C. S. Suh et al., “p-GaN/AlGaN/GaN Enhancement-Mode HEMTs,” 2006 64th Device Research Conference, June 2006, pp. 163-164 (“ <i>Suh2006</i> ”)
Ex. 1039	Supplemental Declaration of James Richard Shealy, Ph.D. in Support of Petitioner’s Opposition To Patent Owner’s Motion To Amend (“ <i>ShealyOpp.</i> ”), Dated September 4, 2024.
Ex. 1040	U.S. Patent Publication No. 2006/1045189 A1 to Beach et al. (“ <i>Beach189</i> ”)
Ex. 1041	Beach Jr, Robert Andrew. Column III nitride growth, characterization and devices. California Institute of Technology, 2001 (“ <i>BeachThesis</i> ”)

All emphasis added unless otherwise noted herein.

I. INTRODUCTION

Patent Owner's proposed substitute claims 13 and 14 are impermissible under 35 U.S.C. §316(d)(3). *First*, the claims lack written description for the new limitation "wherein the semi-insulating III-N layer comprises a compensated GaN layer containing acceptor type dopant atoms passivated with hydrogen" because the specification describes "semi-insulating" and "compensated" layers as separate and different. *Second*, the amendments broaden the claims by expanding "semi-insulating III-N layer" to comprise a "compensated GaN layer." *Third*, the patent does not enable the claims. It provides no guidance at all on how to implement the multi-dimensional parameter space of GaN layer thickness, doping concentration, and passivation to make a "semi-insulating III-N layer [that] comprises a compensated GaN layer containing acceptor type dopant atoms passivated with hydrogen" in an "enhancement mode" device.

The new claims are also unpatentable under 35 U.S.C. § 103 over *Smith*, *Smith/Kigami*, *Smith/Uemoto*, and *Sheu/Kigami*.¹

¹ Patent Owner breached its duty to disclose because it failed to disclose material prior art asserted in the parallel ITC proceeding, including *Sheu*, *Beach189*, and *BeachThesis*. 37 C.F.R. § 42.11. And the motion did not address grounds of unpatentability there or in this IPR. 37 CFR § 42.121(a)(2)(i).

II. THE AMENDMENTS INTRODUCE NEW MATTER, BROADEN THE CLAIMS, AND ARE NOT ENABLED

A. The Patent Lacks Written Description Support

Proposed claims 13 and 14 should be rejected for lack of written description support for a “semi-insulating III-N layer [that] comprises a compensated GaN layer containing acceptor type dopant atoms passivated with hydrogen.” § 316(d)(3); Paper 17, 4-7; ShealyOpp, §V.A.

The '294 patent never describes a “semi-insulating III-N layer” that “comprises a compensated GaN layer.” ShealyOpp, [024]-[038]; *Novozymes A/S v. DuPont Nutrition Biosciences APS*, 723 F.3d 1336, 1349 (Fed. Cir. 2013) (“an ‘amalgam of disclosures’ from which an artisan could have created the claimed invention does not satisfy [the written description] requirement”); *Stored Value Sols., Inc. v. Card Activation Techs., Inc.*, 499 F. App'x 5, 13-14 (Fed. Cir. 2012) (amended claims requiring three authorization codes invalid where specification disclosed no embodiment with all three codes); *Flash-Control, LLC v. Intel Corp.*, No. 2020-2141, 2021 WL 2944592 at *4 (Fed. Cir. July 14, 2021) (no “written description support by picking and choosing claim elements from different embodiments that are never linked together in the specification”).

The patent instead describes a “compensated GaN layer” and “semi-insulating layer” differently—not interchangeably or mixed. ShealyOpp, [024]-[038]; *SimpleAir, Inc. v. Sony Ericsson Mobile Commc'ns AB*, 820 F.3d 419, 431 (Fed. Cir.

2016) (presuming different meanings for different terms) (quoting *Bd. of Regents of the Univ. of Tex. Sys. v. BENQ Am. Corp.*, 533 F.3d 1362, 1371 (Fed. Cir. 2008)). The field of invention distinguishes these terms, stating “the invention relates to an enhancement mode GaN transistor with a compensated GaN layer **or** a semi-insulating GaN layer.” Ex. 1001, 1:14-17. The summary draws the same distinction, describing two embodiments, one “with a compensated GaN layer” and “another ... employing a semi-insulated layer.” *Id.*, 2:11-19.

The patent never describes embodiments with a semi-insulating layer **comprising** a compensated GaN layer. ShealyOpp, [025]-[026]. While the ’294 patent notes “a GaN transistor may have **both** a semi-insulating layer **and** a compensated semiconductor layer,” Ex. 1001, 3:60-61, this describes two different layers, not one comprised in another. ShealyOpp, [027]; Ex. 1001, 3:60-61. For Figures 2-9, the patent only discloses “compensated semiconductor layer 38” without mentioning a “semi-insulating III-N layer.” *Id.*, 2:56-3:52. In contrast, Figures 10-13 disclose a “second embodiment” with “a semi-insulating layer 39 **in place of** the compensated semiconductor layer 38.” *Id.*, 2:56-3:52. The patent again distinguishes compensated and semi-insulating in the “third embodiment” of Figures 14-15, which contains a semi-insulating layer without a compensated layer. Ex. 1001, 4:30-34. The final embodiment of Figure 16 likewise includes a semi-insulating layer without a compensated layer. *Id.*, 4:63-5:2, Fig. 16.

The patent employs different methods to make these layers—with hydrogen passivation for the “compensated layer” but without passivation for the “semi-insulating” layer. *Compare* Ex. 1001, 3:43-52, 5:18-20 (compensated) *with id.*, 3:53-5:2, 5:24-6:5 (semi-insulated). Hydrogen passivation purportedly distinguishes the compensated GaN of Figures 2-9 from the prior art. *Id.*, 3:43-52, claim 2. The patent alleges “[t]he critical step in the above process that differentiates the device of the present invention from the prior art device (FIG. 1) is the passivation of a p-type impurity using hydrogen” which ostensibly results in “compensated semiconductor layer 38 [being] a highly compensated semi-insulating material.” *Id.*, 3:43-52. The patent never describes using hydrogen passivation for the “semi-insulating” layer. *Id.*, 3:53-5:2, 3:53-62, claims 5-6, claim 8. Instead, the “semi-insulating layer” contains “deep acceptor type dopants.” *Id.*

The patent does not explain how to mix and match impurities or overlap “compensated” and “semi-insulating” layers. ShealyOpp, [025]-[028]. The patent consistently employs passivated impurities for the “compensated” layer while using deep level impurities for the “semi-insulating” layer. On one hand, “[c]ompensated semiconductor layer 38 preferably comprises AlGaN or GaN with a deep level *passivated p-type* impurity such as, for example, **Mg, Zn, Be, Cd, or Ca.**” Ex. 1001, 3:10-12, claims 1-3. On the other hand, “[s]emi-insulating layer 39 may comprise,

for example, AlGaN or GaN, with *deep level* impurity atoms, for example, *C, Fe, Mn, Cr, V, or Ni.*” Ex. 1001, 3:57-59, claims 4-6.

In fact, the “p-type impurity[ies]” and “deep level impurity atoms” are from different groups of the periodic table with different properties when in a III-N layer. ShealyOpp, [032]. “**P-type impurities**” create holes and can be passivated to prevent mobile charge, while “**deep level dopants**” have traps that prevent mobile charge. *Id.* The “semi-insulating” and “compensated GaN” are thus separate, distinct layers made from different materials and processes. *Id.*

Passivated p-type impurities

Deep level impurity atoms

Periodic Table of the Elements

1 1A																	18 VIII 8A																		
1 H Hydrogen 1.008	2 IIA He Helium 4.003																	2																	
3 Li Lithium 6.941	4 Be Beryllium 9.012																	5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180												
11 Na Sodium 22.990	12 Mg Magnesium 24.305	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948											19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.933	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.61	33 As Arsenic 74.922	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
37 Rb Rubidium 84.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.905	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.29	55 Cs Cesium 132.905	56 Ba Barium 137.327	57-71 Lanthanide Series	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [209]	85 At Astatine [210]	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103 Actinide Series	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Nh Nihonium [284]	114 Fl Flerovium [289]	115 Uup Ununpentium [289]	116 Lv Livermorium [293]	117 Uus Ununseptium [294]	118 Uuo Ununoctium [294]																		
																		57 La Lanthanum 138.905	58 Ce Cerium 140.115	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.24	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.966	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.50	67 Ho Holmium 164.930	68 Er Erbium 167.26	69 Tm Thulium 168.934	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967			
																		89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]			

Co-inventor Dr. Beach described the differences between compensated and semi-insulating consistent with the specification. ShealyOpp, [033]-[035]. When questioned by Chief Administrative Law Judge Cheney in the related ITC

investigation, Dr. Beach testified a “compensated” GaN is passivated with hydrogen while a “semi-insulating” GaN has a “trap approach.” Ex. 1034, 394:12-395:7. On redirect, Dr. Beach testified “semi-insulating focuses more on the resistance” and “something in it is a trap that prevents the charge from moving in the insulator.” *Id.*, 402:7-19. That testimony aligns with the patent’s use of “passivated p-type impurities” in “compensated layers” and its use of “deep level impurity atoms” for “semi-insulating” layers, which have traps preventing mobile charge. ShealyOpp, [034]-[035].

Dr. Beach’s testimony also accords with the patent’s description that a semi-insulating layer “is not as sensitive to future processing steps involving hydrogen and/or high temperatures.” Ex. 1001, 3:63-4:3; ShealyOpp, [036]. A compensated layer is “sensitive” to “hydrogen and/or high temperatures” during processing because those steps influence hydrogen passivation. *Id.* Hydrogen diffuses out during high temperature processing steps and decreases passivation. *Id.* In contrast, “deep level impurity atoms” remove mobile charge using traps irrespective of exposure to hydrogen or high temperature processing. *Id.* According to the patent, “compensated” and “semi-insulating” have different characteristics. *Id.*

The below table summarizes differences between compensated and semi-insulating layers. ShealyOpp, [037].

Compensated GaN Layer	Semi-Insulating Layer
Embodiment 1: Figures 2-9, Ex. 1001, 2:56-3:52, claims 1-3.	Embodiments 2-4: Figures 10-14, Ex. 1001, 3:53-5:2, claims 4-12.
Passivated	No Passivation
Contains “passivated p-type impurity such as, for example, Mg, Zn, Be, Cd, or Ca.” Ex. 1001, 3:10-15, claims 1-3.	Contains “deep level impurity atoms, for example, C, Fe, Mn, Cr, V, or Ni.” Ex. 1001, 3:57-60, claims 7-8.
“sensitive to future processing steps involving hydrogen and/or high temperatures.” Ex. 1001, 3:63-4:3.	“not as sensitive to future processing steps involving hydrogen and/or high temperatures.” Ex. 1001, 3:63-4:3.
Inventor testimony: hydrogen passivation prevents mobile charge in layer. Ex. 1033, 394:12-395:7, 402:7-19.	Inventor testimony: “trap approach” prevents mobile charge in layer. Ex. 1033, 394:12-395:7, 402:7-19.

The proposed claims accordingly lack written description because they mix layers and impurities the patent solely describes as different. *Novozymes*, 723 F.3d at 1349; *Stored Value Sols.*, at 13-14; *Flash-Control*, at *4; 35 U.S.C. § 316(d)(3).

B. The Amendments Impermissibly Broaden the Claims By Expanding the Definition of “Semi-insulating Layer” to Include “Compensated Layer”

The proposed amendments 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 lack written description support. §II.A; ShealyOpp, §V.B.

Patent Owner irrelevantly notes the patent states “compensated semiconductor layer 38 is a highly compensated semi-insulating material.” Paper 17, 3; Ex. 1001, 3:43-52. Viewed in full, the cited passage only describes the compensated GaN layer is not conductive like prior art devices: “in GaN transistor 1, the compensated semiconductor layer 38 is a highly compensated *semi-insulating material*, while in GaN transistor 100 of the prior art, layer 105 is a *conductive p-type material*.” Ex. 1001, 3:43-52; ShealyOpp, [041]. The patent distinguishes “layer” from “material.” *Id.* “Compensated layer 38” has the electrical property of being a “semi-insulating material,” but this does not mean it is or is a part of “semi-insulating layer 39.” §II.A; ShealyOpp, [041].

The proposed amendments thus impermissibly broaden “semi-insulating III-N layer.” *In re Cuozzo Speed Techs., LLC*, 793 F.3d 1268, 1283 (Fed. Cir. 2015); § 316(d)(3). Whether the remaining amendments otherwise narrow the claims is irrelevant. *Id.* at 1283 n.9 (quoting *In re Rogoff*, 261 F.2d 601, 603 (C.C.P.A. 1958)); *Ball Corp. v. United States*, 729 F.2d 1429, 1438 (Fed. Cir. 1984).

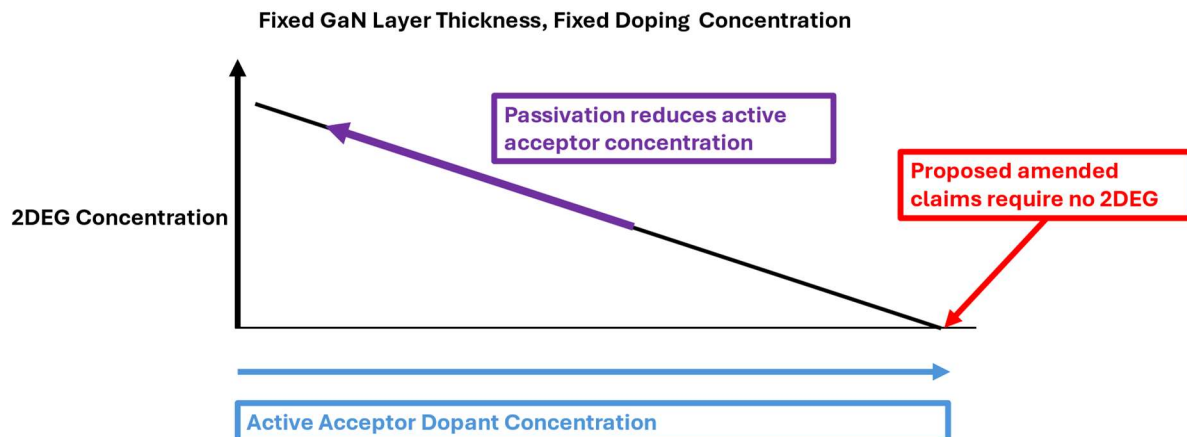
C. The Substitute Claims Are Not Enabled

Claims 13 and 14 recite an “enhancement mode” transistor that includes a “semi-insulating III-N layer [that] comprises a compensated GaN layer containing

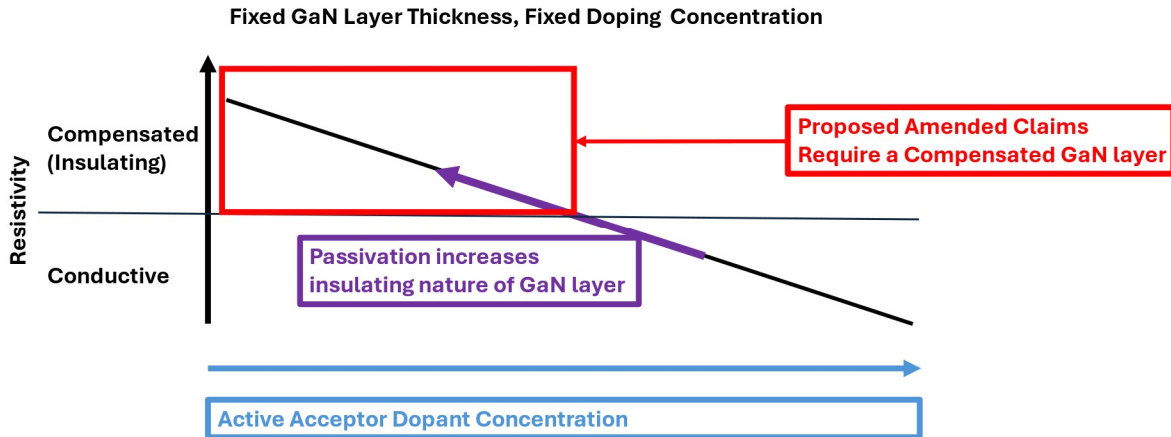
acceptor type dopant atoms passivated with hydrogen” and has “no two-dimensional electron gas (2DEG) region exists below the gate at zero volts applied gate bias.” Claim 14 additionally requires a “MISFET.” A POSITA would have faced undue experimentation to achieve the claimed combinations. ShealyOpp, §V.C.

The '294 patent provides no guidance on key “compensated GaN layer” parameters that control 2DEG depletion and compensation: GaN layer thickness, doping concentration, and passivation. ShealyOpp, [043].

Regarding 2DEG depletion, doping and passivation have competing effects. ShealyOpp, [044]. Less passivation *decreases* the ability of the p-GaN to deplete the 2DEG, making it more difficult to achieve enhancement mode. *Id.*



Regarding a “compensated GaN layer,” the '294 patent explains a “compensated GaN” has an insulating nature, unlike the prior art. Ex. 1001, 3:43-52. Doping and passivation have competing effects on whether the GaN layer is “compensated.” ShealyOpp, [045]. Passivation *increases* its insulating nature. *Id.*



Layer thickness also influences the insulating nature of the GaN layer when passivating with hydrogen. Ex. 1001, 3:37-39. ShealyOpp, [046]. A thicker layer is more difficult to passivate and thus more difficult to compensate. *Id.* Increased thickness can also introduce mobile charge: in a p-GaN surface depletion removes holes, and as the layer becomes thicker, eventually the surface will not deplete the entire layer and mobile charge will be present. *Id.*

Claim 14 further requires a MISFET, which has an insulator in the gate structure, and in embodiments where the gate structure consists only of (1) a gate metal with (2) the semi-insulated or compensated layer, claim 14 would require those layers to be an insulator. ShealyOpp, [047]; *e.g.*, Ex. 1001, Abstract, 2:13-19, 2:56-3:21, claim 10, Fig. 2. To be an insulator with a compensated layer, sufficient acceptors must be passivated. ShealyOpp, [047]. But to deplete the 2DEG for an enhancement mode device requires sufficient active (unpassivated) acceptors. *Id.* These requirements conflict.

The patent is silent regarding these multiple competing parameters, and achieving the proposed combinations of claims 13-14 would thus have required undue experimentation. *ShealyOpp*, [048]. The patent provides no guidance on layer thickness, doping concentration, and passivation to meet the competing goals of depleting the 2DEG to make an enhancement mode device while being “compensated.” *Id.* In view of these tradeoffs, the ’294 patent does not enable the proposed claims. It likewise provides no guidance and does not enable how to create both a MISFET and an enhancement mode device. *ShealyOpp*, [048].

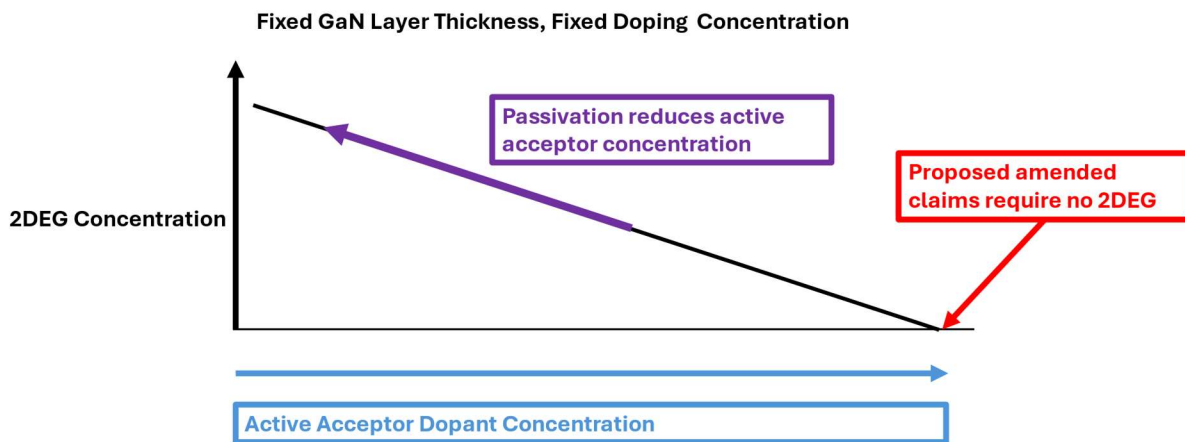
1. **An enhancement mode device would require sufficiently low concentration of free acceptor dopants in the “semi-insulating III-N layer [that] comprises a compensated GaN layer” to deplete the 2DEG**

Proposed claims 13-14 require an “enhancement mode” transistor with “no two-dimensional electron gas (2DEG) region [] below the gate at zero volts applied gate bias.” Paper 17, 4-7.

At least three parameters of the “compensated GaN layer” govern 2DEG depletion: its thickness, doping concentration, and concentration of active acceptors. *ShealyOpp*, [049]-[050]. The 2DEG is removed below the gate when the “compensated GaN layer” contains sufficient sheet charge in the form of “acceptor type dopant atoms” that are *not* “passivated with hydrogen.” *Id.* Passivation inactivates acceptors so they do not contribute to 2DEG depletion. *Id.* Without any

guidance in the patent, determining active acceptor concentration necessary to deplete the 2DEG would require undue experimentation. *Id.*

Doping and passivation have competing effects on the ability of the p-GaN layer to deplete the 2DEG. *Id.*, [051]. For a given thickness and total doping concentration, increased passivation reduces the active acceptor concentration and reduces the ability of the p-GaN layer to deplete the 2DEG. *Id.*



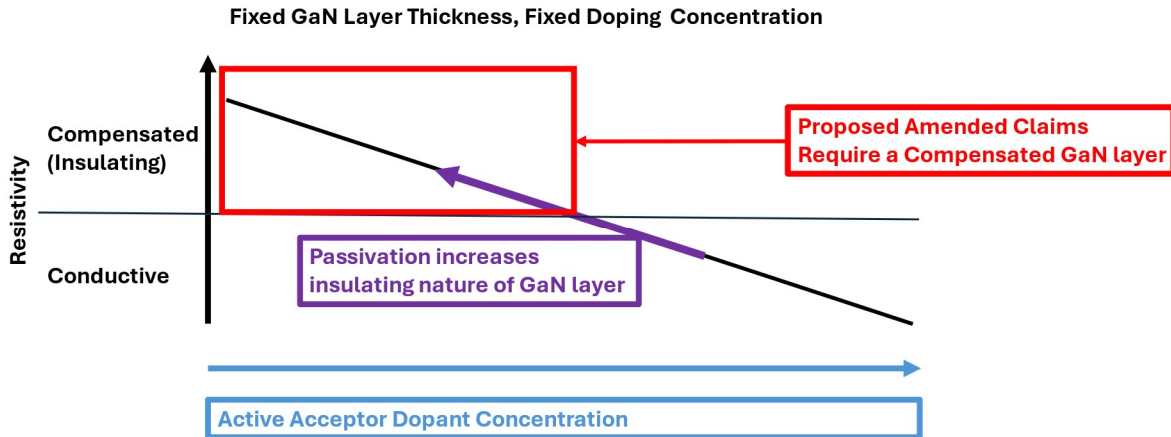
To achieve the claimed “enhancement mode” transistor, active acceptor concentration must be sufficiently **high** to deplete the 2DEG. ShealyOpp, [052]. But there are upper limits on doping, and the layer may need to become thicker to account for the high number of dopants. *Id.* In a thicker layer, however, acceptors are further from the 2DEG and less effective at depleting it. *Id.* And a thicker layer is more difficult to passivate. *Id.* The relationship between active acceptor concentration, total dopant concentration, layer thickness, passivation, and 2DEG

depletion are accordingly complex. The patent does not describe any of these principles or how to achieve the claimed combination of features. *Id.*

2. A “semi-insulating III-N layer [that] comprises a compensated GaN layer” would require sufficiently high concentration of passivated acceptor atoms to insulate and have low gate leakage

The '294 patent describes “compensated layer 38” as “a highly compensated semi-insulating material” that reduces “gate capacitance,” which are alleged differentiating features. Ex. 1001, 3:16-21; 3:43-52. EPC alleged these disclosures support the limitation of “the semi-insulating III-N layer comprises a compensated GaN layer.” Paper No. 17, 3. They do not. *Supra* §II.A-B. But, even if these sections of the patent described “the semi-insulating III-N layer comprises a compensated GaN layer,” they would describe that the “compensated” layer requires sufficient passivation and low concentration of active acceptors to be “semi-insulating material.” ShealyOpp., [053]. Passivation, however, reduces ability to deplete the 2DEG and be an enhancement mode device. *Id.* The patent does not enable how to achieve these competing requirements without undue experimentation. *Id.*

GaN layer thickness, doping, and passivation dictate GaN layer resistivity (insulating nature). ShealyOpp., [054]. Doping and passivation have competing effects on resistivity. *Id.*



Raising active acceptor concentration increases conductivity, and lowering it reduces conductivity. *Id.*

To achieve the claimed “enhancement mode” transistor with no 2DEG below the gate, activated acceptor dopant concentration must be sufficiently *low* to be “compensated” while at the same time achieving no 2DEG below the gate at zero volts applied gate bias. *Id.*, [055]. The patent does not describe how to achieve this combination, which therefore requires undue experimentation. *Id.*

3. The “semi-insulating III-N layer [that] comprises a compensated GaN layer” must be sufficiently thick to deplete the 2DEG and be compensating but not so thick as to have high turn on voltage and high gate leakage

Enhancement mode devices turn on after exceeding a positive threshold voltage. Ex. 1001, 1:53-54; ShealyOpp, [057]. For a p-GaN layer to be insulating, a POSITA knew a thin layer better modulates charge in the channel than a thicker layer. *Id.* For a “semi-insulating III-N layer [that] comprises a compensated GaN

layer containing acceptor type dopant atoms passivated with hydrogen,” a POSITA knew hydrogen passivates a thin layer more easily. *Id.*

But a POSITA would also know a thin layer would require incredibly high concentrations of dopant to have sufficient leftover charge after passivation to deplete the 2DEG and create an enhancement mode device (e.g., to have sufficient active Mg). ShealyOpp, [057]-[058]. Doping this way would be a difficult process and would require much experimentation. *Id.* While doping may be easier by making the layer thicker, the layer then becomes less insulating and harder to passivate. *Id.* And layer thickness has an upper limit because thickness drives turn on voltage in the wrong direction—a thicker layer can result in a negative turn on voltage—depletion not enhancement mode. *Id.*

The '294 patent never describes how to balance these tradeoffs to achieve the claimed device, which would require undue experimentation. ShealyOpp, [058]-[059].

4. The '294 patent provides no guidance on how to achieve the competing requirements of being “semi-insulating comprising a compensated GaN” and being “enhancement mode,” which would require undue experimentation

The patent does not explain how to find the appropriate doping, passivation, and GaN layer thickness to make the devices of claims 13 and 14. ShealyOpp, [060]; *supra* §§II.C.1-II.C.2. Instead, the '294 patent describes the result—a “compensated GaN layer” in an “enhancement mode” device—without describing the means to

achieve it, which fails to meet the enablement requirement. *Regents of the Univ. of Cal. v. Eli Lilly & Co.*, 119 F.3d 1559, 1568 (Fed. Cir. 1997) (“The description requirement of the patent statute requires a description of an invention, not an indication of a result that one might achieve if one made that invention.”). The patent provides no guidance on the range of parameters that would deplete the 2DEG and create a “compensated GaN.” Ex. 1001; ShealyOpp, [060]-[064].

Regarding the claimed passivation, the '294 patent only suggests to “expos[e] the device to ammonia or hydrogen plasma at a high temperature.” Ex. 1001, 3:30-42. This lack of guidance is especially problematic because many factors influence hydrogen passivation, including doping concentration, GaN layer thickness, gas flows, hydrogen exposure time, and temperature. ShealyOpp, [062]. The patent provides none of that information.

Downstream processing steps also influence passivation, but the patent is silent on how to control these steps. ShealyOpp, [063]. The patent discusses implementing an anneal and notes the compensated embodiments are sensitive to processing with hydrogen and/or high temperature but does not explain how to account for anneal. *Id.*; Ex. 1001, 3:67-4:5. In an anneal, hydrogen diffuses out, reducing passivation. ShealyOpp, [063]. The patent does not describe how to do this when making an enhancement mode device with a “compensated GaN layer.” *Id.*

Under any proposed definition, a POSITA would not have been able to identify the narrow range of GaN layer thickness, doping concentration, and passivation that meet the proposed claims without undue experimentation (if such a range indeed exists). *ShealyOpp*, [064]. The claims are thus not enabled, as a POSITA would have needed to perform hundreds—even thousands—of experiments to arrive at the claimed device (if ever). *Amgen Inc. v. Sanofi*, 598 U.S. 594, 612-16 (2023); *Baxalta Inc. v. Genetech, Inc.*, 81 F.4th 1362, 1364-68 (Fed. Cir. 2023).

5. The patent does not describe how to make the “compensated gate enhancement mode MISFET” with a p-GaN passivated with hydrogen as required in Claim 14

Proposed claim 14 requires (1) a “MISFET,” (2) “enhancement mode,” (3) a “semi-insulating III-N layer [that] comprises compensated GaN layer containing acceptor type dopant atoms passivated with hydrogen.” These requirements present trade-offs and inconsistencies. *ShealyOpp*, [065]-[071]. Yet the patent does not explain how to make such a device, forcing a POSITA to engage in undue experimentation to attempt the claimed combination. *Id.*

First, MISFET stands for Metal Insulator Field Effect Transistor. *ShealyOpp*, [066]. The claimed MISFET has an insulating layer below the gate contact, and the patent discloses a MISFET when the gate structure consists of a gate contact with

either a compensated or semi-insulating layer. Ex. 1001, Abstract, 2:13-19, 2:56-3:21, claim 10, Fig. 2. *Id.*

Second, an enhancement mode p-GaN must have fixed negative charge in the form of activated p-type dopants to deplete the 2DEG. ShealyOpp, [067]. But the patent does not describe how to achieve a “MISFET” with fixed negative charge in the layer below the gate to make it “enhancement mode.” *Id.*

Third, claim 14 requires a “semi-insulating III-N layer [that] comprises compensated GaN layer containing acceptor type dopant atoms passivated with hydrogen.” The patent does not describe or enable this limitation. §§II.A, II.C.1-II.C.4; ShealyOpp, [068].

To a POSITA these three points lead to competing requirements as summarized in the table below. *Id.*, [066]-[070]. The patent provides no guidance on how to balance them without undue experimentation.

Claim Term	Condition in Claimed Device
MISFET	p-GaN layer below the gate must be insulating.
Enhancement mode	p-GaN layer below the gate must have active p-type acceptor atoms to deplete the 2DEG.
compensated GaN layer containing acceptor type dopant atoms passivated with hydrogen	p-GaN layer below the gate is passivated and is insulating. Passivation will reduce the ability to deplete the 2DEG.

III. THE PROPOSED CLAIMS ARE OBVIOUS

A. The Claims Are Obvious and Not Enabled

Enablement and obviousness are different. Enablement addresses whether a POSITA can make and use the claims' full scope. *Nat'l Recovery Techs., Inc. v. Magnetic Separation Sys., Inc.*, 166 F.3d 1190, 1195-96 (Fed. Cir. 1999). But to invalidate the claims under § 103, the prior art need only render obvious **an** embodiment within the claim scope. *In re Mraz*, 455 F.2d 1069, 1073 (C.C.P.A. 1972); *DNT, LLC v. Sprint Spectrum, LP*, 750 F. Supp. 2d 616, 624 (E.D. Va. 2010) (“[I]t is possible for a claim to be obvious because of various prior art references while still non-enabled given severe deficiencies in the claim specification.”). Further, a reference is presumed operable for purposes of invalidity when it discloses the challenged claims. *In re Sasse*, 629 F.2d 675, 681 (C.C.P.A. 1980); *In re Stauffer*, 290 Fed. Appx. 327, 333 (Fed. Cir. 2008) (claims obvious over disclosure “effectively identical” to patent). And enablement of a prior art reference under § 103 is held to a lower standard than § 112. *Impax Labs. Inc. v. Aventis Pharms. Inc.*, 468 F.3d 1366, 1381-82 (Fed. Cir. 2006) (“[P]roof of efficacy is not required.”).

Here, the claims are not enabled. §II.C. And the prior art renders obvious the claims under different interpretations of [13e.2] and [14c.2].

B. Interpretations of [13e.2] and [14c.2]

“[W]herein the semi-insulating III-N layer **comprises** a compensated GaN layer” as recited in of [13e.2] and [14c.2] can be interpreted as (i) the “compensated

GaN layer” *is* the “semi-insulating III-N layer” or (ii) the “compensated GaN layer” is included in a larger “semi-insulating III-N layer.” ShealyOpp, [072]-[073].

For the first interpretation, a GaN layer with a “passivated p-type impurity such as, for example, Mg, Zn, Be, Cd, or Ca,” above a barrier and below a gate contact discloses [13e.1]/[14c.1]. ShealyOpp, [074]; Ex. 1001, 3:10-12, claims 1-3. When passivated with hydrogen, it also discloses [13e.2]. *Id.*

For the second interpretation, a GaN layer with “deep level impurity atoms, for example, C, Fe, Mn, Cr, V, or Ni” that is above a barrier layer and below a gate contact discloses the “semi-insulating III-N layer” of [13e.1]/[14c.1]. ShealyOpp, [075]; Ex. 1001, 3:57-59, claims 4-6. If the layer comprises a subregion with a “passivated p-type impurity such as, for example, Mg, Zn, Be, Cd, or Ca,” it discloses [13e.2]. Ex. 1001, 3:10-12, claims 1-3; ShealyOpp, [075].

Limitation	<u>Interpretation i:</u> “compensated GaN layer” is a “semi-insulating III-N layer”	<u>Interpretation ii:</u> “compensated GaN layer” is included in a larger “semi-insulating III-N layer”
[13e.1]/[14c.1] a semi-insulating III-N layer [above the barrier layer/ between the barrier layer and the gate contact]	Prior art GaN layer with a “passivated p-type impurity such as, for example, Mg, Zn, Be, Cd, or Ca ” above a barrier layer and below a gate contact.	Prior art GaN layer with “deep level impurity atoms, for example, C, Fe, Mn, Cr, V, or Ni ” above a barrier layer and below a gate contact.
[13e.2]/[14c.2] wherein the semi-insulating III-N layer comprises a compensated GaN layer containing acceptor type dopant atoms passivated with hydrogen	GaN layer of [13e.1]/[14c.1] is passivated with hydrogen.	GaN layer of [13e.1]/[14e.1] contains a region with a “p-type impurity such as, for example, Mg, Zn, Be, Cd, or Ca ” passivated with hydrogen.

The prior art grounds are as follows:

“compensated GaN layer” is a “semi-insulating III-N layer” “compensated GaN layer” is included in a larger “semi-insulating III-N layer”	
Ground 1.A.i: <i>Smith</i> renders obvious Claims 13 and 14	Ground 1.A.ii: <i>Smith</i> renders obvious Claims 13 and 14
Ground 1.B.i: <i>Smith</i> in view of <i>Kigami</i> renders obvious Claims 13 and 14	Ground 1.B.ii: <i>Smith</i> in view of <i>Kigami</i> renders obvious Claims 13 and 14
Ground 1.C.i: <i>Smith</i> in view of <i>Uemoto</i> renders obvious Claims 13 and 14	Ground 1.C.ii: <i>Smith</i> in view of <i>Uemoto</i> renders obvious Claims 13 and 14
Ground 2.A: <i>Sheu</i> in view of <i>Kigami</i> renders obvious Claims 13 and 14	Ground 2.A.ii: <i>Sheu</i> in view of <i>Kigami</i> renders obvious Claims 13 and 14

C. The New Claims Are Unpatentable Over *Smith*, *Smith/Kigami*, and *Smith/Uemoto*

1. Motivation to combine *Smith/Kigami* and *Smith/Uemoto*

a. Interpretation i: “compensated GaN layer” is a “semi-insulating III-N layer”

The Petition explains a POSITA would have been motivated to combine *Smith* with *Kigami* or *Uemoto*. Petition, 21-33; ShealyOpp, [079].

b. Interpretation ii: “compensated GaN layer” is included in a larger “semi-insulating III-N layer”

Smith discloses embodiments where **cap layer 34** is GaN, co-doped with deep level and p-type dopants throughout, but heavily p-doped in region 40. *Smith*, [0085]-[0087]; *ShealyOpp*, [080]-[083]. Figure 2A shows **cap layer 34** above **barrier layer 22**, below **gate contact 32**, and between **ohmic contacts 30**. *Id.* A POSITA would have found it obvious to passivate **cap layer 34** with hydrogen to control acceptor concentration while reducing gate leakage. *Id.*, [084]-[086]; *ShealyPet*, [0123]-[0140].

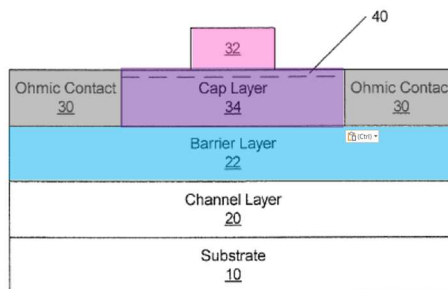


Figure 2A

Smith incorporates *Saxler874* to teach co-doping. *Smith*, [0085]. *Saxler874* describes doping so the cap layer’s Mg concentration is lower than the deep level dopant concentration. *Saxler874*, [0005]-[0006]; *ShealyOpp*, [086]. Additionally, a POSITA would have been motivated to passivate **cap layer 34** with hydrogen in co-doping embodiments to make the portion below region 40 insulating. *ShealyOpp*, [086]. Because *Smith*’s incorporation of *Saxler874* leads to lower p-type dopant concentration in the portion of **cap layer 34** below region 40 than in region 40, this

portion would be fully passivated (insulating) while maintaining active acceptor concentration in region 40. *Id.*; *Smith*, [0085]; *Saxler* 874, [0005]-[0006].

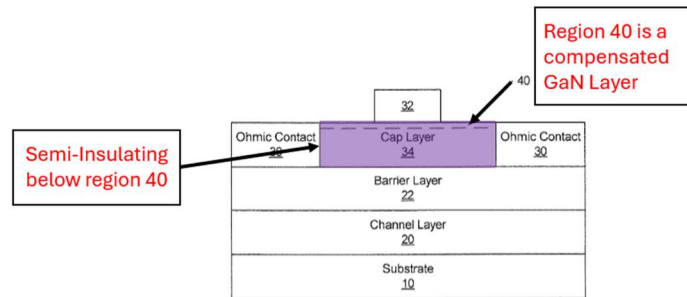


Figure 2A

2. Claim 13

a. [13p]

As explained for [1p], *Smith* discloses a “column III nitride transistor.” *Pet.*, 34; *ShealyPet*, [0142]. *Smith* also discloses an “enhancement mode” transistor. *ShealyReply*, [046]-[059]. For example, *Smith* discloses a p-type doped GaN cap layer below the gate and above an AlGaN barrier, where region 40 may be heavily doped p-type. *Smith*, [0014], [0017], [0085]-[0087]; *ShealyOpp*, [088]-[089].

b. [13a]

As explained for [1a], *Smith*’s **substrate 10** is “a substrate.” *Petition*, 34-35; *ShealyOpp*, [090].

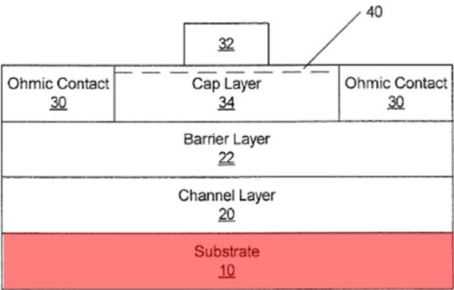


Figure 2A

c. [13b]

As explained for [1b], *Smith*’s **transition layers** are “a set of III-N transition layers above the substrate.” *Petition*, 35-36; *ShealyOpp*, [091].

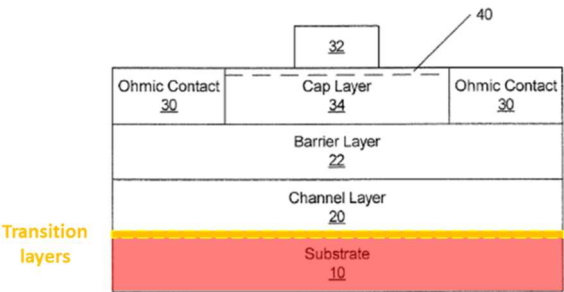


Figure 2A

d. [13c]

As explained for [1c], *Smith*’s **channel layer 20** is “a III-N buffer layer above the set of transition layers.” *Petition*, 36-37; *ShealyOpp*, [092].

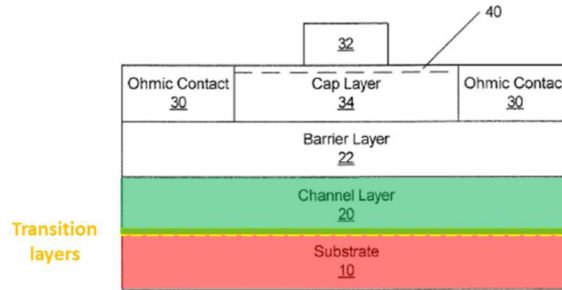


Figure 2A

e. [13d]

As explained for [1d], *Smith*'s **barrier layer 22** is “a III-N barrier layer above the buffer layer.” Petition, 37-38; ShealyOpp, [093].

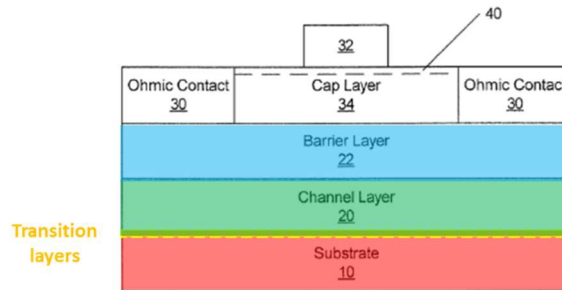


Figure 2A

f. [13e.1]

i. **Interpretation i: “compensated GaN layer” is a “semi-insulating III-N layer”**

As explained for [1e], *Smith* alone or in view of *Kigami* or *Uemoto* renders obvious “a compensated GaN layer above the barrier layer” under Petitioner’s proposed construction or Patent Owner’s original proposed construction. Petition, 21-26, 38-43; ShealyOpp, [094]-[097]. And *Smith*, alone or in view of *Kigami* or

Uemoto, also renders obvious a “compensated GaN layer above the barrier layer” under Patent Owner’s revised construction. Paper 26, §III.B.3; ShealyReply, §III.C.

For Grounds 1A (*Smith*), 1B (*Smith/Kigami*), and 1C (*Smith/Uemoto*), it would have been obvious that **cap layer 34** (taught by *Smith* or as modified by *Kigami* or *Uemoto*) is a “compensated GaN layer” above **barrier layer 22** renders obvious a “compensated GaN layer above the barrier layer.” Petition, 21-26, 38-43; ShealyOpp, [096]-[097].

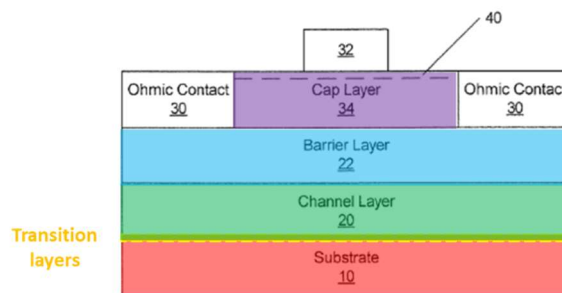


Figure 2A

ii. Interpretation ii: “compensated GaN layer” is included in a larger “semi-insulating III-N layer”

As explained for [4e], *Smith*’s **cap layer 34**, which is above **barrier layer 22**, discloses “a semi-insulating III-N layer above the barrier layer” when containing deep level dopants. Petition, 46-48; ShealyPet, [0175]-[0176]. *Smith*’s deep level dopants “Fe, C, V, Cr, Mn, Ni and/or Co” overlap with the ’294 patent’s examples “C, Fe, Mn, Cr, V, or Ni.” Ex. 1001, 3:57-59, claims 4-6. Like the ’294 patent, *Smith*’s semi-insulating layer is AlGaN or GaN, doped with deep level impurity atoms. Compare *Smith*, [0089] with ’294 patent, 2:66-67.

Smith also discloses co-doping GaN **cap layer 34** with both deep level dopants such as “Fe, C, V, Cr, Mn, Ni and/or Co” *and* a “p-type dopant, such as Mg, Be, Zn, Ca and/or C.” *Smith*, [0085] (incorporating *Saxler874*); *Saxler874*, [0005]-[0006]. This discloses the “semi-insulating layer” of [13e.1]. Ex. 1001, 3:57-59, claims 4-6; *ShealyOpp*, [098]-[099].

g. [13e.2]

i. Interpretation i: “compensated GaN layer” is a “semi-insulating III-N layer”

Smith’s **cap layer 34** renders obvious a “compensated GaN layer” under any proposed construction. §III.C.2.f.i ([13e.1]). Further, as explained for claim 2, *Smith*, *Smith/Kigami*, or *Smith/Uemoto* each also renders obvious that the **cap layer 34** “contain[s] acceptor type dopant atoms passivated with hydrogen” as required in [13e.2]. Petition 21-33, 44-45; *ShealyOpp*, [0100].

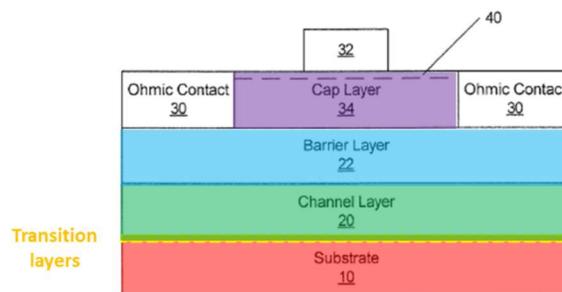


Figure 2A

ii. Interpretation ii: “compensated GaN layer” is included in a larger “semi-insulating III-N layer”

As explained for [13e.1], co-doped embodiments of **cap layer 34** render obvious a “semi-insulating III-N layer.” §III.C.2.f.ii.

Within **cap layer 34**, *Smith* discloses subregion 40, which is a “compensated GaN layer containing acceptor type dopant atoms,” as recited in [13e.2]. ShealyOpp, [0102]. Region 40 may be doped heavily p-type. *Smith*, [0085], [0087].

The concentration of p-type dopants in region 40 is higher than deep level dopants to control gate leakage. *Smith*, [0085], [0087]; ShealyOpp, [0103]. Thus, heavily p-typed doped region 40 is a “compensated GaN layer containing acceptor type dopants” within the larger cap layer 34, which is a “semi-insulating III-N layer” because it contains deep acceptor atoms in *Smith*’s co-doped embodiments.

Figure 2A shows **cap layer 34** above **barrier layer 22** and region 40 within the cap layer.

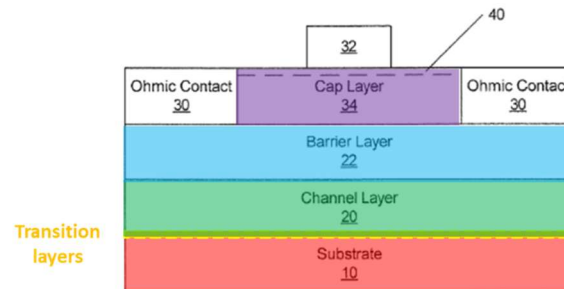


Figure 2A

Smith alone and/or in view of *Kigami* or *Uemoto* render obvious “wherein the semi-insulating III-N layer comprises a compensated GaN layer containing acceptor type dopant atoms *passivated with hydrogen*” of [13e.2] for the same reasons provided with respect to [1e] and claim 2 when discussing embodiments that are

only doped p-type. Petition, 21-33, 38-43, 44-45; ShealyPet, [0105]-[0122], [0151]-[0168]; ShealyOpp, [0105].

A POSITA would have understood that hydrogen would have been naturally incorporated into the cap layer to passivate dopants, including in region 40. ShealyOpp, [0106]; ShealyPet, [0113]-[0114]. *Smith* would have motivated a POSITA to control active acceptor concentration using well-known methods of hydrogen passivation to reduce gate leakage. ShealyOpp, [0106]; ShealyPet, [0123]-[0127]. And a POSITA would also have been motivated to implement *Kigami*'s and *Uemoto*'s methods of using hydrogen to passivate and control active dopant concentrations in *Smith*'s device and reduce gate leakage. ShealyPet, [0128]-[0140].

h. [13f]

Smith, *Smith/Kigami*, or *Smith/Uemoto* render obvious “a gate comprising a gate contact and the compensated GaN layer.” ShealyOpp, [0108]-[0115]. As explained for [1f], **gate contact 32** is a “gate contact” above **cap layer 34**. Petition, 43; ShealyPet, [0164]. *Smith*'s **cap layer 34** alone and/or as modified in *Smith/Kigami* or *Smith/Uemoto* render obvious the “compensated GaN layer” under both interpretations. §§III.C.2.g.i-III.C.2.g.ii. In Grounds 1A-1C, therefore, *Smith*'s **gate contact 32** and **cap layer 34** form a “gate comprising a gate contact and the compensated GaN layer.”

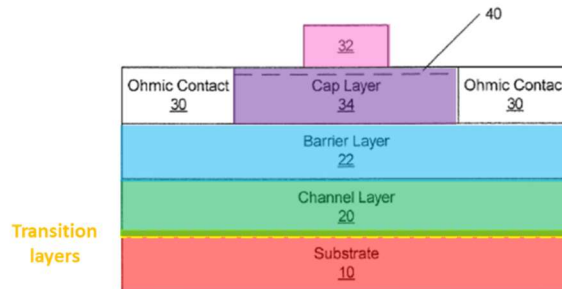


Figure 2A

i. **Interpretation i: “compensated GaN layer” is a “semi-insulating III-N layer”**

Smith alone renders obvious an “enhancement mode” device because **cap layer 34** is doped p-type, below the gate, and above an AlGaN barrier. §III.C.2.a; *ShealyReply*, [047]-[053].

Although passivation reduces the ability to deplete the 2DEG, a POSITA would have found it obvious to use passivation that results in enhancement mode given the knowledge of a POSITA and the disclosures of doping, thicknesses, and concentration ranges in *Smith*, and the techniques for localized passivation and resistivity control in *Uemoto* and *Kigami*. *ShealyOpp*, [0111]-[0115].

A POSITA knew that hydrogen would have been naturally incorporated into the cap layer and passivated dopants, including in region 40. *ShealyOpp*, [0113]. 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. *Id.*; *Smith* [0077], [0087]. Further, *Kigami* and *Uemoto* describe techniques for localized hydrogenation of GaN layers.

ShealyOpp, [0114]; *Kigami*, [0036]; *Uemoto*, [0062]. *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. ShealyOpp, [0114]. When passivating with hydrogen to reduce gate leakage with well-known methods, a POSITA would have maintained an active dopant concentration that depleted the 2DEG. ShealyOpp, [0115]. A POSITA would have done so to realize the benefits of enhancement mode devices, including reduced power consumption and suitability for high power applications (e.g., higher threshold voltage and added safety in power switching, high power applications). *Suh2006*, 1.

ii. Interpretation ii: “compensated GaN layer” is a “semi-insulating III-N layer”

In the *Smith* grounds, a POSITA would have understood hydrogen impurities (from *Smith*'s MOCVD, *Kigami*'s hydrogenation, or *Uemoto*'s hydrogen diffusion) would passivate region 40. §III.C.2.g.ii. Further, it would have been obvious to passivate the cap layer with hydrogen to reduce gate leakage. ShealyOpp, [0116]-[0117]; §III.C.2.g.i. Based on knowledge and disclosures in *Smith*, *Kigami*, and *Uemoto*, a POSITA would have made *Smith*'s device so active acceptor concentration resulted in an enhancement-mode device. ShealyOpp, [0119]. It would have been obvious to do so to realize the benefits of enhancement mode devices,

including reduced power consumption and suitability for high power applications).

ShealyOpp, [0119]-[0120]; *Suh2006*, 1.

3. Claim 14

a. [14p]

i. Interpretation i: “compensated GaN layer” is a “semi-insulating III-N layer”

As explained for [13p], *Smith*’s **cap layer 34** is compensated and p-type doped in an enhancement mode transistor. §III.C.2.a. Additionally, *Smith*, alone or in combination with *Uemoto* or *Kigami*, discloses MISFETs as explained for [10p]. ShealyOpp, [0122]-[0123]; ShealyPet, [0195]-[0198]. *Smith* discloses “in the embodiments illustrated in FIG. 3B, a MISHEMT may be provided.” *Smith*, [0095].

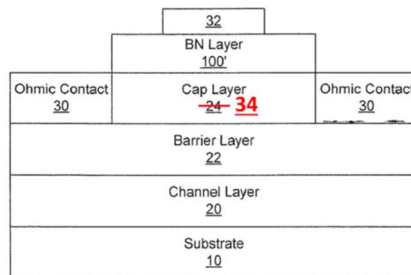


Figure 3B

Because cap layer 34 may be p-type doped, *Smith*’s MISFET operated in enhancement mode. ShealyOpp, [0124]-[0125]; *Smith*, [0087]. When **cap layer 34** is p-type doped it would deplete the 2DEG at 0V applied gate voltage. ShealyOpp, [0124]; ShealyReply, §IV.A. EPC’s expert Dr. Schubert agreed: “if a p-type gate

material is present over the barrier layer, it can deplete the 2DEG under the gate to create an enhancement mode, i.e., normally ‘OFF’, transistor.” Ex. 2009 ¶ 31.

b. [14a]

As explained for [10a], **barrier layer 22** is a III-N barrier layer beneath **gate contact 32**. Petition, 54-55; ShealyOpp, [0126].

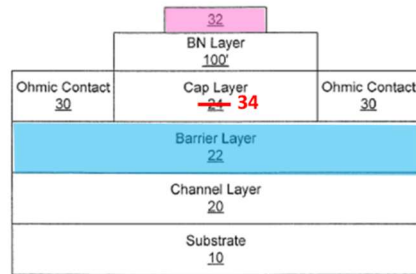


Figure 3B

c. [14b]

As explained for [10b], *Smith*’s **ohmic contacts 30** of Figure 3B disclose “a drain contact, a source contact.” Petition, 55-56; *Smith*, [0090]; ShealyOpp, [0127].

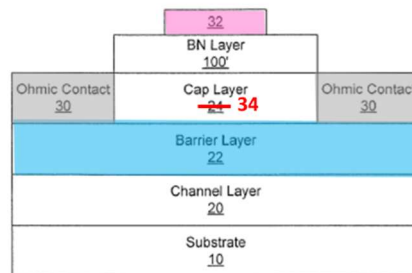


Figure 3B

d. [14c.1]

[14c.1] and [13e.1] require “a semi-insulating III-N layer.” As explained for [13e.1], *Smith*’s **cap layer 34**, alone or in view of *Kigami* or *Uemoto*, renders

obvious a “semi-insulating III-N layer” under either interpretation. §§III.C.2.f.i, III.C.2.f.ii; ShealyOpp, [0128]-[0129].

[14c.1] requires that the “semi-insulating III-N layer is *between the barrier layer and the gate contact.*” **Cap layer 34** is between **gate contact 32** and **barrier layer 22**. *Smith*, [0090].

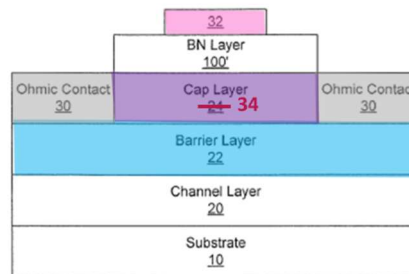


Figure 3B

e. [14c.2]

As explained for [13e.2], *Smith*, *Smith/Kigami*, or *Smith/Uemoto* render obvious [14c.2]. §§III.C.2.g.i, III.C.2.g.ii; ShealyOpp, [0131].

f. [14d]

As explained for [13f], *Smith*, *Smith/Kigami*, or *Smith/Uemoto* renders obvious [14d]. §§III.C.2.h.i, III.C.2.h.ii; ShealyOpp, [0132].

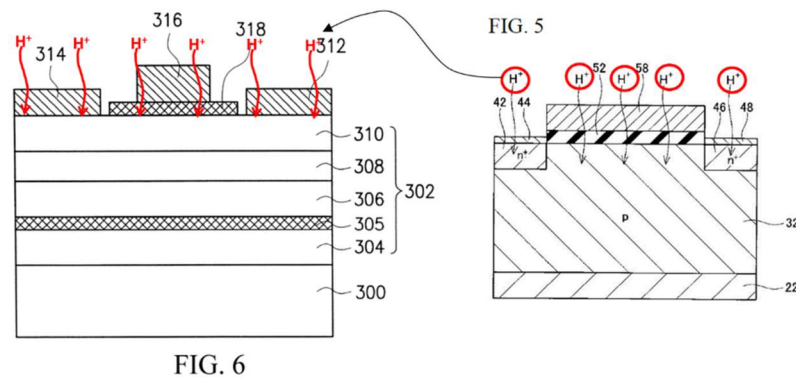
D. The New Claims Are Unpatentable in View of *Sheu/Kigami*

1. Motivation to combine *Sheu* and *Kigami*

It would have been obvious to apply *Kigami*’s technique to *Sheu*’s transistors. ShealyOpp, §[0132]-[0141]. A POSITA would have done so to passivate

magnesium in *Sheu*'s "gate insulating layer 318" to adjust resistivity and achieve advantages of localized hydrogenation. *Id.*; *Kigami*, [0007]-[0012].

Sheu discloses a HEMT with gate insulating layer 318 doped "to enhance the resistance value." *Sheu*, 9-10. It was well-known that hydrogen passivated GaN layer dopants and enhanced resistivity. *Petition*, 8-10; *ShealyPet*, [060]-[064]. A POSITA would have applied *Kigami*'s hydrogenation to passivate magnesium in gate insulating layer 318 and control resistivity, as shown below. *ShealyOpp*, [0132]-[0134].



Multiple rationales support this combination. *ShealyOpp*, [0135]-[0141].

First, *Sheu* and *Kigami* both disclose III-nitride transistors and target the same problems of breakdown voltage and gate leakage. *Id.* [0136].

Second, *Kigami* explicitly suggests and motivates such a combination. *Id.*, [0137]. *Kigami* teaches its technique improves characteristics of devices with magnesium dopants. *Id.*; *Kigami*, [0012], [0029]. *Sheu* discloses doping with magnesium and seeks to improve the same characteristics. *Sheu*, 10. A POSITA,

therefore, would have applied *Kigami*'s teachings to *Sheu*. ShealyOpp, [0137]-[0139].

Third, a POSITA would have recognized the combination used a known technique (*Kigami*'s hydrogenation to locally passivate GaN layers) in a known device (*Sheu*'s transistor) ready for improvement. ShealyOpp, [0140]; *Kigami*, [0012]; *Sheu*, 10. *Kigami*'s hydrogenation improves III-nitride transistors, like *Sheu*'s, by adjusting layer resistivity, controlling threshold voltage, enhancing breakdown voltage, and permitting high-frequency applications. *Kigami*, [0007]-[0008], [0029]. A POSITA would have recognized *Kigami*'s hydrogenation techniques would improve *Sheu*'s device. ShealyOpp, [0140].

Fourth, a POSITA would have expected to succeed in controlling *Sheu*'s layers resistance in applying *Kigami*'s hydrogenation because such passivation had been known for decades and *Kigami* adequately explains the passivation process and its effects. ShealyOpp, [0141]; *Kigami*, [0022]-[0026].

2. Claim 13

a. [13p]

Sheu discloses “a high electron mobility transistor (HEMT)” formed with GaN-based layers because GaN is III-N. ShealyOpp, [0142]-[0147]; *Sheu*, 5-9; Fig. 6.

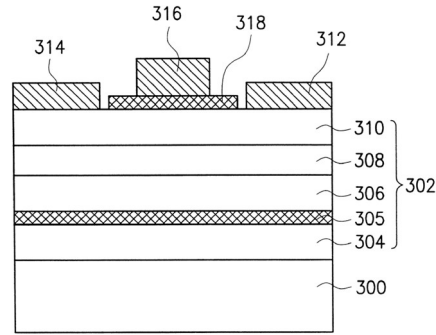


FIG. 6

A POSITA would have recognized *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.” ShealyOpp, [0145]-[0147]; *Sheu*, 9-10. To a POSITA 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. ShealyOpp, [0146] (citing Exs. 1014-1015). Even Dr. Schubert agreed, “if a p-type gate material is present over the barrier layer, it can deplete the 2DEG under the gate to create an enhancement mode.” Ex. 2009, ¶ 31. That is the same configuration in *Sheu/Kigami*, where p-type doped layer 318 is over barrier layer 310, and thus depletes the 2DEG to create the enhancement mode transistor of [13p]. ShealyOpp, [0147].

b. [13a]

Sheu discloses “substrate 300.” *Sheu*, 9; ShealyOpp, [0148]-[0149].

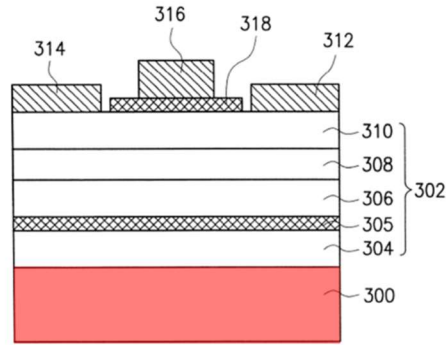


FIG. 6

c. [13b]

Sheu discloses “buffer layer 304” and “isolation layer 305.” *ShealyOpp*, §VI.B.2.c. These are AlN and AlGaN layers, which the ’294 patent specifies for the “set of III-N transition layers.” *Id.*; *Sheu*, 10; Ex. 1001, 1:59-60. **Buffer layer 304** and **isolation layer 305** are [13b]’s “set of III-N transition layers” and are above **substrate 300**. *ShealyOpp*, [0150]-[0152].

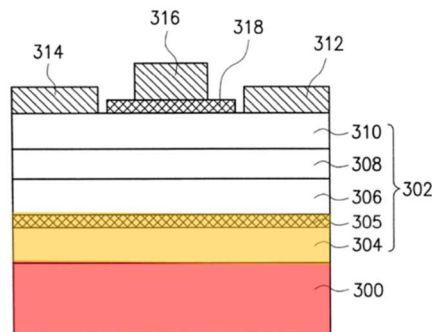


FIG. 6

d. [13c]

Sheu discloses “channel layer 306” and “gap layer 308.” *ShealyOpp*, [0153]-[0155]; *Sheu*, 10. These are GaN layers, which the ’294 patent specifies for the “III-N buffer layer.” *Id.*; Ex. 1001, 1:60. *Sheu*’s “channel layer 306” and “gap layer 308”

constitute [13c]’s “III-N buffer layer.” Further, **channel layer 306** and **gap layer 308** are above **buffer layer 304** and **isolation layer 305**.

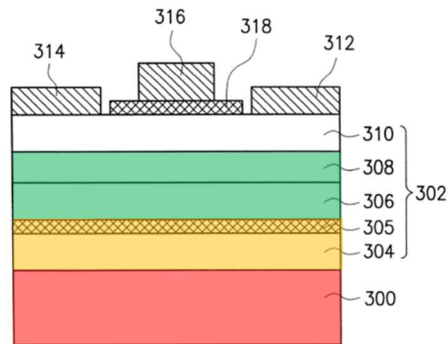


FIG. 6

e. [13d]

Sheu discloses a “**barrier layer 310**.” *ShealyOpp*, [0156]-[0158]. **Barrier layer 310** is AlGa_N, which the ’294 patent specifies for the “III-N barrier layer.” *Id.*; *Sheu*, 10; Ex. 1001, 1:61-62. **Barrier layer 310** is located above **channel layer 306** and **gap layer 308**.

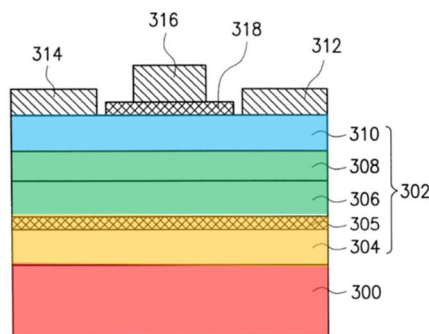


FIG. 6

f. [13e.1]

- i. Interpretation i: “compensated GaN layer” is a “semi-insulating III-N layer”

Sheu/Kigami renders obvious “a semi-insulating III-N layer above the barrier layer” in [13e.1] under the first interpretation of [13e.2] by disclosing “**gate insulating layer 318**” is p-type doped with magnesium, and subject to *Kigami*’s hydrogenation. ShealyOpp, [0159]-[0165]. **Gate insulating layer 318** is GaN and above **barrier layer 310**. *Id.*

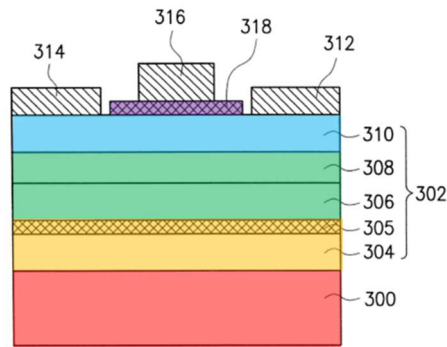


FIG. 6

In *Sheu/Kigami*, **gate insulating layer 318** is “compensated” under any construction. ShealyOpp, [0161]-[0165]. **Gate insulating layer 318** is magnesium doped, and *Sheu* describes a desired resistance of 10^9 to 10^{12} ohms/sq. *Sheu*, 9-10. *Kigami* teaches the intentional passivation of magnesium acceptors in p-type GaN layers, like *Sheu*’s **gate insulating layer 318**, to enhance resistance. ShealyOpp, [0162]-[0163]. A POSITA would have applied *Kigami*’s hydrogenation to passivate magnesium and control resistivity in **gate insulating layer 318**, making the layer “compensated” under any construction. ShealyOpp, [0164]-[0165].

ii. Interpretation ii: “compensated GaN layer” is included in a larger “semi-insulating III-N layer”

Sheu/Kigami meets [13e.1] under the second interpretation of [13e.2] because **gate insulating layer 318**, which is above **barrier layer 310**, is co-doped with magnesium and iron and subject to *Kigami*'s hydrogenation. ShealyOpp, [0166]-[0171]; *Sheu*, 10. A POSITA knew that such co-doping yields a "semi-insulating III-N layer. ShealyOpp, [0167]. In *Saxler874* the combination of magnesium and iron dopants creates a semi-insulating layer. *Saxler874*, [0005]; ShealyOpp, [0168]; ShealyPet, [0175]-[0176]. *Saxler874* discloses co-doping for "fabrication of a semi-insulating Group III nitride layer" using p-type dopant Mg" and "deep level transition metal dopant [] Fe," like *Sheu*. *Saxler874*, [0005]-[0006]; *Sheu* 10.

Further, *Sheu* describes **gate insulating layer 318** has a resistance of 10^9 - 10^{12} ohms/sq, which a POSITA would have identified as "semi-insulating," and formed with the dopant the '294 patent associates with "semi-insulating III-N layer:" GaN doped with iron. ShealyOpp, [0169]-[0171]; *Sheu*, 9-10; Ex. 1001, 2:66-67.

g. [13e.2]

i. Interpretation i: "compensated GaN layer" is a "semi-insulating III-N layer"

Sheu/Kigami meet [13e.2] under its first interpretation. ShealyOpp, [0172]-[0173]. As explained for [13e.1], when *Sheu*'s **gate insulating layer 318** is doped with magnesium and subject to *Kigami*'s hydrogenation, the layer is a "compensated GaN layer" under any proposed construction. §III.C.2.f. *Sheu/Kigami* also meet "compensated GaN layer containing acceptor type dopant atoms passivated with

hydrogen” because **gate insulating layer 318** is doped with magnesium and *Kigami* teaches hydrogenation to passivate magnesium. ShealyOpp, [0173].

ii. Interpretation ii: “compensated GaN layer” is included in a larger “semi-insulating III-N layer”

Sheu/Kigami renders obvious [13e.2] under its second interpretation. ShealyOpp, [0174]-[0184]. Embodiments of **gate insulating layer 318** co-doped with magnesium and iron meet the “semi-insulating III-N layer.” §III.D.2.f. Further, **gate insulating layer 318** comprises a “compensated GaN layer” under any proposed construction when *Kigami*’s hydrogenation is applied to locally passivate magnesium in regions of **gate insulating layer 318**. ShealyOpp, [0175].

Kigami’s technique creates a layer where “hydrogen atoms are *unevenly distributed* in a local region of the III-V group compound semiconductor,” and *Kigami* controls hydrogen introduction with, for example, “material[s] through which it is difficult for hydrogen ions to pass.” *Kigami*, [0008], [0026]; ShealyOpp, [0176]-[0177]. It would have been obvious to apply *Kigami*’s technique to form **gate insulating layer 318** with uneven hydrogen distribution to create regions of **gate insulating layer 318** with high hydrogen concentration to passivate magnesium dopants (“compensated GaN layer”) while others regions with lower hydrogen concentration that remain co-doped and “semi-insulating.” ShealyOpp, [0177].

Kigami’s uneven hydrogen distribution in **gate insulating layer 318** is depicted below, with areas immediately below gate 316 (purple-hashed pattern)

having a lower hydrogen concentration than the regions not immediately below **gate 316** (purple without hashed pattern). *Id.*, [0178].

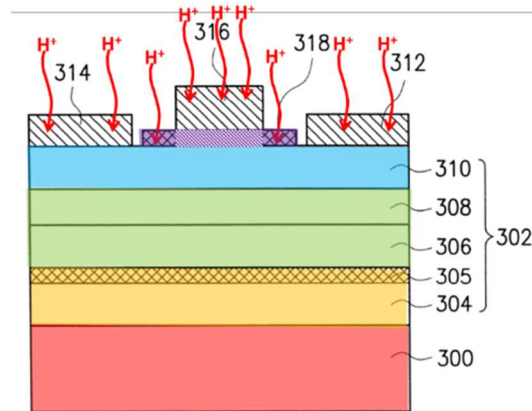


FIG. 6

A POSITA would have formed **gate 316** with “a material through which it is difficult for hydrogen ions to pass.” *Kigami*, [0026]; *ShealyOpp*, [0178]. A POSITA would have implemented *Kigami*’s hydrogenation per the drawing above and based on *Kigami*’s teachings to, for example, reduce gate leakage current by passivating edges (like described in *Uemoto*) or better control the 2DEG channel. *ShealyOpp*, [0179]-[0181]

Sheu/Kigami’s compensated GaN layer(s) of **gate insulating layer 318** contain the “acceptor type dopant atoms passivated with hydrogen” of [13e.2]. In the example, these layers would have acceptor dopants (*Sheu*’s magnesium) passivated with hydrogen (*Kigami*’s localized hydrogenation). *ShealyOpp*. [0183]-[0184].

h. [13f]

i. Interpretation i: “compensated GaN layer” is a “semi-insulating III-N layer”

Sheu/Kigami meets [13f] under the first interpretation of [13e.2]. *ShealyOpp*, [0186]-[0190]. **Gate 316** is a “gate contact.” *Id.* And in the combination, **gate insulating layer 318** is doped with magnesium and passivated with hydrogen (a “compensated GaN layer”). §III.D.2.g. Further, **gate insulating layer 318** and **gate 316** are the “gate comprising a gate contact and the compensated GaN layer” in [13f]. *ShealyOpp*, [0186]-[0187].

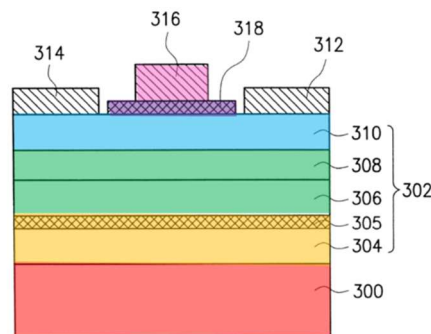


FIG. 6

Having “no two-dimensional electron gas (2DEG) region [that] exists below the gate at zero volts applied gate bias” would have been obvious to a POSITA. §III.D.2.a; *ShealyOpp*, [0188]. *Sheu/Kigami* teaches an “enhancement mode” device because *Sheu*’s **gate insulating layer 318** is p-type doped with magnesium. §III.D.2.a. A p-doped layer below the gate and above an AlGaN barrier layer creates an enhancement mode device. *ShealyOpp*, [0188]-[0189]. When doped with magnesium, **gate insulating layer 318** is “a p-type gate material [that] is present

over the barrier layer[and] can deplete the 2DEG under the gate to create an enhancement mode,” as even Dr. Schubert would agree. Ex. 2009, ¶ 31; §III.D.2.a; ShealyOpp, [0189]-[0190].

ii. Interpretation ii: “compensated GaN layer” is a “semi-insulating III-N layer”

Sheu/Kigami describes **gate 316** and a “compensated GaN layer” in **gate insulating layer 318** resulting from *Kigami*’s uneven hydrogen distribution. §III.D.2.g; ShealyOpp, [0191]-[0193].

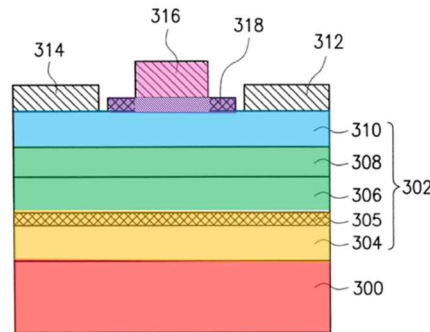


FIG. 6

Having “no two-dimensional electron gas (2DEG) region [that] exists below the gate at zero volts,” would have been obvious because the *Sheu/Kigami* combination results in an enhancement-mode device. §III.D.2.h; ShealyOpp, [0193]. A POSITA would have understood that when doped with magnesium and iron, **gate insulating layer 318** is “a p-type gate material [that] is present over the barrier layer [and] can deplete the 2DEG under the gate to create an enhancement mode,” as even Dr. Schubert would agree. Ex. 2009 ¶ 31; §III.D.2.a.

3. Claim 14

a. [14p]

As explained for [13p], *Sheu/Kigami* discloses that **gate insulating layer 318** is p-type doped with magnesium and subject to *Kigami*'s hydrogenation. §III.D.2.a; *ShealyOpp*, [0194]-[0197]. *Sheu/Kigami Sheu* explicitly discloses the MISFET limitation because it seeks a “metal-insulating layer-semiconductor field effect transistor (MISFET) [that] has good electrical characteristics.” *Sheu*, 4-5. *Sheu* discloses the MIS structure: a metal (**gate 316**), on an insulating layer (**gate insulating layer 318**), on a semiconductor (**barrier layer 310**). *ShealyOpp*, [0194]-[0197].

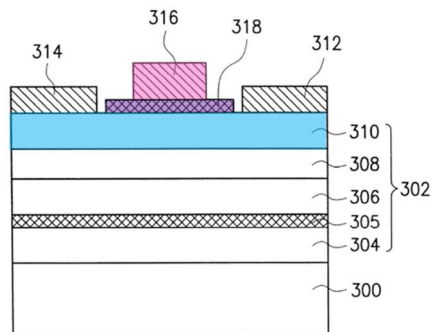


FIG. 6

b. [14a]

Sheu discloses **barrier layer 310** beneath the **gate 316**. *Sheu*, 10; *ShealyOpp*, [0198].

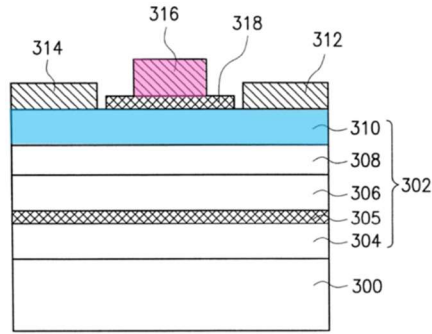


FIG. 6

c. [14b]

Sheu discloses **source 312**, and **drain 314**. *Sheu*, 9. ShealyOpp, [0199].

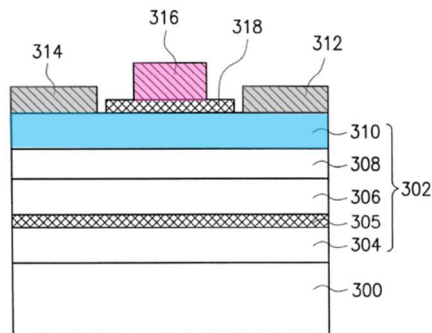


FIG. 6

d. [14c.1]

[14c.1] and [13e.1] require “a semi-insulating III-N layer.” As explained for [13e.1] **gate insulating layer 318** of *Sheu/Kigami* renders obvious “semi-insulating III-N layer” under either interpretation of [14c.2]. §III.D.2.f.

Sheu also discloses **gate insulating layer 318** between **gate 316** and **barrier layer 310** as required in [14c.1]. ShealyOpp, [0200]-[0201].

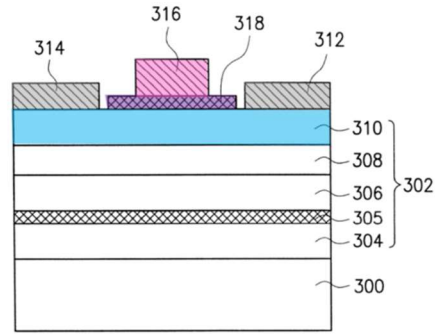


FIG. 6

e. [14c.2]

Sheu/Kigami render obvious [14c.2]. §III.D.2.g; ShealyOpp, [0202].

f. [14d]

Sheu/Kigami render obvious [14c.2]. §III.D.2.h; ShealyOpp, [0203].

IV. CONCLUSION

The Board should deny EPC's motion to amend.

Dated: September 4, 2024

/Lionel M. Lavenue/
Lionel M. Lavenue (Reg. No. 46,859)
Counsel for Petitioner

APPENDIX A: CLAIM LISTING

1. **[1p]** A column III Nitride transistor comprising:
 - [1a]** a substrate,
 - [1b]** a set of III-N transition layers above the substrate,
 - [1c]** a III-N buffer layer above the set of transition layers,
 - [1d]** a III-N barrier layer above the buffer layer,
 - [1e]** a compensated GaN layer above the barrier layer, and
 - [1f]** a gate contact above the compensated GaN layer.
2. The transistor of claim 1, wherein the compensated GaN layer contains acceptor type dopant atoms passivated with hydrogen.

The transistor of claim 2, where the acceptor type atoms are selected from the group consisting of Mg, Zn, Be and Ca.
4. **[4p]** A column III Nitride transistor comprising:
 - [4a]** a substrate,
 - [4b]** a set of III-N transition layers above the substrate,
 - [4c]** a III-N buffer layer above the set of transition layers,
 - [4d]** a III-N barrier layer, and
 - [4e]** a semi-insulating III-N layer above the barrier layer.
5. The transistor of claim 4, wherein the semi-insulating III-N layer contains deep acceptor type dopant atoms.

6. The transistor of claim 5 where the deep acceptor type atoms are selected from the group consisting of C, Fe, Mn, Cr and V.
7. **[7p]** A column III Nitride transistor comprising:
 - [7a]** a substrate,
 - [7b]** a set of III-N transition layers above the substrate,
 - [7c]** a III-N buffer layer above the set of transition layers,
 - [7d]** a III-N barrier layer,
 - [7e]** a semi-insulating III-N layer above the barrier layer, and
 - [7f]** a confinement layer above the semi-insulating III-N layer.
8. The transistor of claim 7, wherein the semi-insulating III-N layer contains deep acceptor type dopant atoms selected from the group consisting of C, Fe, Mn, Cr and V.
9. The transistor of claim 7, wherein the confinement layer is made of SiN, SiO₂, Al₂O₃, HfO₂, Ga₂O₃, or InAlGa₂N.
10. **[10p]** A compensated gate MISFET transistor comprising:
 - [10a]** a III-N barrier layer beneath a gate contact,
 - [10b]** a drain contact, a source contact, and
 - [10c]** a semi-insulating III-N layer between the barrier layer and the gate contact.

11. The transistor of claim 10, further comprising a confinement layer above the semi-insulating III-N layer.
12. The transistor of claim 10, further comprising a spacer layer between the semi-insulating layer and the barrier layer.
13. **[13p]** An enhancement mode [A] column III nitride transistor comprising:
 - [13a]** a substrate,
 - [13b]** a set of III-N transition layers above the substrate,
 - [13c]** a III-N buffer layer above the set of transition layers,
 - [13d]** a III-N barrier layer above the buffer layer, [and]
 - [13e.1]** a semi-insulating III-N layer above the barrier layer, **[13e.2]** wherein the semi-insulating III-N layer comprises a compensated GaN layer containing acceptor type dopant atoms passivated with hydrogen, and
 - [13f]** a gate comprising a gate contact and the compensated GaN layer, wherein no two-dimensional electron gas (2DEG) region exists below the gate at zero volts applied gate bias.
14. **[14p]** A compensated gate enhancement mode MISFET transistor comprising:
 - [14a]** a III-N barrier layer beneath a gate contact,
 - [14b]** a drain contact, a source contact, and
 - [14c.1]** a semi-insulating III-N layer between the barrier layer and the gate contact, **[14c.2]** wherein the semi-insulating III-N layer comprises a

compensated GaN layer containing acceptor type dopant atoms
passivated with hydrogen, and

[14d] a gate comprising the gate contact and the compensated GaN layer,
wherein no two-dimensional electron gas (2DEG) region exists below
the gate at zero volts applied gate bias.

CERTIFICATION OF COMPLIANCE WITH WORD COUNT

Petitioner certifies that the word count under for the foregoing Petitioners' Opposition to Patent Owner's Motion to Amend totals 7,749 words as measured by the word-processing system used to prepare this paper and has 49 pages. The word and page counts are less than the 8,000 words and 50 pages permitted by the Board for this document in the Board's email dated August 30, 2024.

Dated: September 4, 2024

By: /Lionel M. Lavenue/

Lionel M. Lavenue

Reg. No. 46,859

CERTIFICATE OF SERVICE

Pursuant to 37 CFR § 42.6(e)(4), the undersigned certifies that on September 4, 2024, a complete and entire copy of this Petitioner's Opposition to Patent Owner's Motion to Amend was provided by email, to the Patent Owner, by serving the correspondence email address of record as follows:

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