

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

GLOBALFOUNDRIES U.S., INC. and GLOBALFOUNDRIES, INC.,
Petitioners,

v.
OAK IP, LLC,
Patent Owner.

Case No. IPR2025-00889
Patent No. 10,090,395

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 10,090,395**

TABLE OF CONTENTS

I.	INTRODUCTION	1
II.	MANDATORY NOTICES	5
A.	Real Parties-in-Interest (37 C.F.R. § 42.8(b)(1))	5
B.	Related Matters (37 C.F.R. § 42.8(b)(2)).....	5
1.	Judicial Matters	5
2.	Administrative Matters	6
C.	Lead and Back-Up Counsel:	6
D.	Service Information:.....	7
III.	PAYMENT OF FEES	7
IV.	GROUND FOR STANDING.....	7
V.	PRECISE RELIEF REQUESTED AND GROUNDS RAISED.....	8
A.	Identification of Prior Art.....	8
1.	Grupp '483 (Ex.1021).....	8
2.	Jammy (Ex.1101).....	8
B.	Statutory Grounds of Unpatentability	9
VI.	OVERVIEW OF PRIOR ART	9
A.	Grupp '483	9
B.	Jammy.....	9
VII.	OVERVIEW OF THE '395 PATENT	10
A.	Technical Background.....	10
B.	The Purported Invention of the '395 Patent.....	13
C.	Prosecution History	13

D.	Prior Litigation and IPR Petitions	16
1.	District Court.....	16
2.	PTAB.....	16
VIII.	CLAIM CONSTRUCTION	17
IX.	LEVEL OF ORDINARY SKILL	18
X.	PRIORITY DATE OF THE CHALLENGED CLAIMS	19
A.	Claims 11-14 and 17-28	20
B.	Claim 7	21
C.	Claims 29 and 30.....	21
XI.	'395 PATENT AND ITS PARENT APPLICATIONS DO NOT ADEQUATELY DESCRIBE THE GENUS OF "OXIDE OF TITANIUM".....	21
A.	Genus of "oxide of titanium" is extremely broad	21
1.	Genus of "oxide of titanium" includes numerous binary compounds composed of oxygen and titanium	22
2.	Genus of "oxide of titanium" includes numerous ternary compounds composed of oxygen, titanium, and another element	24
B.	Ancestor applications of the '395 Patent fail to adequately describe an interface layer that comprises an "oxide of titanium"	31
1.	Electrical conductivity (or resistivity)	35
2.	Barrier height	37
3.	Electron affinity	39
4.	Bandgap energy.....	40
5.	Dielectric constant.....	41

6.	Structural properties	42
7.	Melting point	43
8.	Optical transparency	43
XII.	THE CHALLENGED CLAIMS ARE UNPATENTABLE.....	48
A.	Ground 1: Grupp '483 anticipates Claims 17-28	48
1.	Claim 17	48
2.	Claim 18	52
3.	Claim 19	53
4.	Claim 20	53
5.	Claim 21	54
6.	Claim 22	54
7.	Claim 23	54
8.	Claim 24	56
9.	Claim 25	56
10.	Claim 26	57
11.	Claim 27	57
12.	Claim 28	57
B.	Ground 1: Grupp '483 anticipates claims 7 and 11-14	58
1.	Claim 7	58
2.	Claim 11	59
3.	Claim 12	59
4.	Claim 13	60
5.	Claim 14	60

C.	Ground 2: Jammy renders claims 29 and 30 obvious	64
1.	Claim 29	64
2.	Claim 30	76
XIII.	THE DISCRETIONARY FACTORS	77
XIV.	CONCLUSION.....	77

LIST OF EXHIBITS

Exhibit	Description
1001	U.S. Patent No. 10,090,395
1002	File History of U.S. Patent No. 7,084,423
1003	U.S. Patent No. 7,084,423
1004	File History of U.S. Patent No. 6,833,556
1005	U.S. Patent No. 6,833,556
1006	File History of U.S. Patent No. 7,462,860
1007	U.S. Patent No. 7,462,860
1008	File History of U.S. Patent No. 7,884,003
1009	U.S. Patent No. 7,884,003
1010	File History of U.S. Patent No. 8,431,469
1011	U.S. Patent No. 8,431,469
1012	File History of U.S. Patent No. 9,425,277
1013	U.S. Patent No. 9,425,277
1014	File History of U.S. Patent No. 9,905,691
1015	U.S. Patent No. 9,905,691
1016	File History of U.S. Patent No. 9,812,542
1017	U.S. Patent No. 9,812,542
1018	File History of U.S. Patent No. 10,388,748
1019	U.S. Patent No. 10,388,748
1020	File History of U.S. Patent No. 10,090,395
1021	U.S. Patent No. 7,176,483 (“Grupp ’483”)
1022	Declaration of Dr. E. Fred Schubert (“Schubert Decl.”)
1023	E.H. Rhoderick, <i>Metal-Semiconductor Contacts</i> , 129 IEE Rev. 1 (Feb. 1982) (“Rhoderick”)
1024	C.Y. Chang et al., <i>Specific Contact Resistance Of Metal-Semiconductor Barriers</i> , 15 Solid State Elecs. 541 (1971) (“Chang”)
1025	S.M. Goodnick et al., <i>Effects of a Thin SiO₂ Layer On The Formation Of Metal-Silicon Contacts</i> , 18 J. Vac. Sci. & Tech. 949 (Apr. 1981) (“Goodnick”)
1026	M.A. Sobolewski and C.R. Helms, <i>Studies Of Barrier Height Mechanisms In Metal-Silicon Nitride-Silicon Schottky Barrier Diodes</i> , J. Vac. Sci. & Tech. B 971 (Jul./Aug. 1989) (“Sobolewski”)
1027	U.S. Patent No. 4,110,488 (“Risko”)

Exhibit	Description
1028	M.A. Taubenblatt et al., <i>Interface Effects In Titanium And Hafnium Schottky Barriers On Silicon</i> , 44 Applied Physics Letters 895 (“Taubenblatt 1984”)
1029	U.S. Patent No. 3,983,264 (“Schroen”)
1030	U.S. Patent No. 4,845,050 (“Kim”)
1031	Japanese Laid-Open App. No. JPH11162874A (June 18, 1999)
1032	Certified Translation of Japanese Laid-Open App. No. JPH11162874A (June 18, 1999) (“Iwaguro”)
1033	D. Brassard et al., <i>Tuning The Electrical Resistivity Of Pulsed Laser Deposited Tisio X Thin Films From Highly Insulating To Conductive Behaviors</i> , 84 Applied Physics Letters 2304 (2004) (“[2004-Brassard]”)
1034	Redline of Specification of U.S. Patent No. 7,176,483 Against Specification of U.S. Patent No. 7,084,423
1035	D. Brassard and M.A. El Khakani, <i>Pulsed-Laser Deposition Of High-K Titanium Silicate Thin Films</i> , 98 J. Applied Physics 054912 (2005) (“[2005-Brassard]”)
1036	D. Brassard et al., <i>Substrate Biasing Effect On The Electrical Properties Of Magnetron-Sputtered High-K Titanium Silicate Thin Films</i> , 102 J. Applied Physics 034106 (2007) (“[2007-Brassard]”)
1037	U.S. Patent App. Pub. No. 2014/0117465 (“Huang”)
1038	Complaint, <i>Acorn Semi, LLC v. Samsung Elecs. Co., Ltd.</i> , No. 2:19-cv-00347, ECF No. 1 (E.D. Tex. Oct. 23, 2019)
1039	Blank
1040	Blank
1041	Blank
1042	Exhibit F to Acorn’s Preliminary Infringement Contentions, <i>Acorn Semi, LLC v. Samsung Elecs. Co., Ltd.</i> , No. 2:19-cv-00347 (Mar. 9, 2020)
1043	Redacted Acorn’s Opposition to Samsung’s Motion for Judgment, <i>Acorn Semi, LLC v. Samsung Elecs. Co., Ltd.</i> , No. 2:19-cv-00347, ECF No. 401 (E.D. Tex. Sept. 2, 2021)
1044	E. Piner Trial Demonstratives, Redacted Acorn’s Opposition to Samsung’s Motion for Judgment, Ex.B-1, <i>Acorn Semi, LLC v. Samsung Elecs. Co., Ltd.</i> , No. 2:19-cv-00347, ECF No. 401-3 (E.D. Tex. Sept. 2, 2021)
1045	Verdict Form, <i>Acorn Semi, LLC v. Samsung Elecs. Co., Ltd.</i> , No. 2:19-cv-00347 (May 19, 2021)

Exhibit	Description
1046	N.F. Mott and L. Friedman, <i>Metal-Insulator Transitions in VO₂, Ti₂O₃ and Ti_{2-x}V_xO₃</i> , 30 Philosophical Magazine 389 (1974) (“[1974-Mott]”)
1047	S. Åsbrink and A. Magnéli, <i>Crystal Structure Studies on Trititanium Pentoxide, Ti₃O₅</i> , 12 Acta Crystallographica 575 (1959) (“[1959- Åsbrink]”)
1048	Dr. Kuhn’s Deposition Transcript, July 6, 2021
1049	Dr. Kuhn’s Deposition Transcript, July 7, 2021
1050	M.G. Kostenko et al., <i>Simulation of the Short-Range Order in Disordered Cubic Titanium Monoxide TiO_{1.0}</i> , 97 JETP Letters 616 (2013) (“[2013-Kostenko]”)
1051	A.A. Valeeva and M.G. Kostenko, <i>Stable Ti₉O₁₀ Nanophase Grown From Nonstoichiometric Titanium Monoxide TiO_y Nanopowder</i> , 8 Nanosystems: Physics, Chemistry, Mathematics 816 (2017) (“[2017-Valeeva]”)
1052	D. Gerlich et al., <i>Thermoelastic Properties of ULE® Titanium Silicate Glass</i> , 21 J. Non-Crystalline Solids 243 (1976) (“[1976-Gerlich]”)
1053	F.Y. Robb, <i>Plasma Etching of Oxygen Containing Titanium Silicide Films</i> , 131 J. Electrochem. Soc’y 2906 (1984) (“[1984-Robb]”)
1054	K. Stella et al., <i>Charge Transport Through Thin Amorphous Titanium and Tantalum Oxide Layers</i> , 158 J. Electrochem. Soc’y 5 (Mar. 28, 2011) (“[2011-Stella]”)
1055	S. Lee et al., <i>Tunnel Barrier Engineering of Titanium Oxide For High Non-Linearity of Selector-Less Resistive Random Access Memory</i> , 104 Applied Physical Letters (Feb. 7, 2014). (“[2014-Lee]”)
1056	Murray et al., <i>The O-Ti (Oxygen-Titanium) System</i> , 8(2) J. Phase Equilibria 148-165 (1987) (“[1987-Murray]”)
1057	S.K.J. Al-Ani et al., <i>The Optical Absorption Edge of Amorphous Thin Films of Silicon Monoxide</i> , 19 J. Materials Sci. 1737 (1984) (“1984-Al-Ani”)
1058	G.L. Tian et al., <i>Effect of Microstructure of TiO₂ Thin Films on Optical Band Gap Energy</i> , 22 Chinese Physical Soc’y 7 (February 25, 2006) (“[2005-Tian]”)

Exhibit	Description
1059	J. Wang et al., <i>High-Performance Photothermal Conversion of Narrow-Bandgap TiO₂ Nanoparticles</i> , 29 <i>Advance Materials</i> 1603730 (Nov. 11, 2016) (“[2017-Wang]”)
1060	D. Roy and S.B. Krupanidhi, <i>Pulsed Excimer Laser Ablated Barium Titanate Thin Films</i> , 61 <i>Applied Physics Letters</i> 2057 (1992) (“[1992-Roy]”)
1061	J. Hao et al., <i>Dielectric Properties of Pulsed-Laser-Deposited Calcium Titanate Thin Films</i> , 76 <i>Applied Physics Letters</i> 3100 (2000) (“[2000-Hao]”)
1062	G.P. Shveikin, <i>Magnetic Properties of Ti₃O₆ with Chromium Additions</i> , 544 <i>Z. Anorg. Allg. Chem.</i> (1987) (“[1987-Shveikin]”)
1063	S.P. Denker, <i>Electronic Properties of Titanium Monoxide</i> , 37 <i>J. Applied Physics Letters</i> 1 (Jan. 1966) (“[1966-Denker]”)
1064	R. van de Krol et al., <i>Electrical and Optical Properties of TiO₂ in Accumulation and of Lithium Titanate Li_{0.5}TiO₂</i> , 90 <i>J. Applied Physics</i> 2235 (2001) (“[2001-van-de-Krol]”)
1065	F. Imai et al., <i>Interfacial Reaction of MgO/TiO_x Superlattice Thin Films</i> , 228 <i>Thin Solid Films</i> 158 (1993) (“[1993-Ima]”)
1066	CC Vacuum Coating Materials Co, Ltd. (July 21, 2021) http://coatmaterials.com/html_products/TiO-(Titanium-monoxide)-64.html (“[Coat TiO]”)
1067	F.M. Pontes et al., <i>High dielectric constant of SrTiO₃ thin films prepared by chemical process</i> , 35 <i>J. Materials Sci.</i> 4783 (2000) (“[2000-Pontes]”)
1068	M.M. Doeff et al., <i>Titanate Anodes For Sodium Ion Batteries</i> , Lawrence Berkeley Nat’l Lab’y (Jan. 31, 2014), https://escholarship.org/uc/item/2wrlb5xt 24 (“[2014-Doeff]”)
1069	S.D. Mo and W.Y. Ching, <i>Electronic and Optical Properties of Three Phases of Titanium Dioxide: Rutile, Anatase, and Brookite</i> , 51 <i>Physical Rev. B</i> 19 (May 15, 1995) (“[1995-Mo]”)
1070	N.V. Nguyen et al., <i>Optical Properties of Jet-Vapor-Deposited TiAlO and HfAlO Determined by Vacuum Ultraviolet Spectroscopic Ellipsometry</i> , CP683 <i>Characterization and Metrology for ULSI Technology: 2003 International Conference</i> , Am. Inst. Physics (2003) (“[2003-Nguyen]”)
1071	V.-T. Rangel-Kuoppa and A. Conde-Gallardo, <i>Ohmic Contact Recipe on Ti₂Cr₂O₃ and Its Application to Temperature Dependent Hall Measurements</i> , 1566 <i>The Physics of</i>

Exhibit	Description
	<i>Semiconductors</i> , Am. Inst. Physics Conf. Proc. 23 (2013) (“[2013-Rangel-Kuoppa]”)
1072	L.B. Glebov et al., <i>Planar Optical Waveguides on Glasses and Glass-Ceramic Materials</i> , 1513 SPIE Glasses for Optoelectronics II 56 (1991) (“[1991-Glebov]”)
1073	T. Shikama et al., <i>Erosion Behaviour of Physically Vapour-Deposited and Chemically Vapour-Deposited Sic Films Coated on Molybdenum During Oxygenated Argon Beam Thinning</i> , 117 Thin Solid Films 191 (1984) (“[1984-Shikama]”)
1074	N. Szydlo and R. Poirier, <i>I-V and C-V Characteristics of Au/TiO₂ Schottky Diodes</i> , 51 J. Applied Physics 6 (June 1980) (“[1980-Szydlo]”)
1075	CPHMI Phelly Materials Inc, <i>Titanium Oxide (V), Ti₃O₅</i> (July 27, 2021), https://www.phelly.com/ti3o5/ (“[Phelly Ti ₃ O ₅]”)
1076	S.H. Hong, <i>Crystal Growth of Some Intermediate Titanium Oxide Phases γ-Ti₃O₅, P-Ti₃O₅, Ti₄O₇ and Ti₂O by Chemical Transport Reactions</i> , 36 Acta Chemica Scandinavica A (1982) (“[1982-Hong]”)
1077	S. Gwo et al., <i>Local Electric-Field-Induced Oxidation of Titanium Nitride Films</i> , 74 Applied Physics Letters 1090 (1999) (“[1999-Gwo]”)
1078	M. Takeuchi et al., <i>Dielectric Properties of Sputtered TiO₂ Films</i> , 51 Thin Solid Films 83 (1978) (“[1978-Takeuchi]”)
1079	E.T. Fitzgibbons et al., <i>TiO₂ Film Properties as a Function of Processing Temperature</i> , 119 J. Electrochem. Soc. 6 (June 1972) (“[1972-Fitzgibbons]”)
1080	T. Bertaud et al., <i>Ultra Wide Band Frequency Characterization of Integrated Titao-Based Metal–Insulator–Metal Devices</i> , 110 J. Applied Physics 044110 (2011) (“[2011-Bertaud]”)
1081	H. Liu et al., <i>Structural, Electronic, Mechanical, Dielectric and Optical Properties of TiSiO₄: First-Principles Study</i> , 251 Solid State Commc’ns 43 (2017) (“[2017-Liu]”)
1082	D. Hallock et al., <i>Method to Fabricate Low Stress Refractory Metal Silicide Films</i> , 32 IBM Tech. Disclosure Bull. 190 (1989) (“[1989-Hallock]”)
1083	U.S. Patent No. 4,912,286 (“Clarke”)
1084	S. Yang et al., <i>A Novel Carbon Thermal Reduction Approach to Prepare Recorded Purity B-Ti₃O₅ Compacts From Titanium</i>

Exhibit	Description
	<i>Dioxide And Phenolic Resin</i> , 853 J. Alloys & Compounds 157360 (2021) (“[2021-Yang]”)
1085	S. Kashiwaya et al., <i>The Work Function of TiO₂</i> , 2018 Chin. Surfaces. 1 (Sept. 7, 2018) (“[2018-Kashiwaya]”)
1086	S. Bartkowski et al., <i>Electronic Structure of Titanium Monoxide</i> , 56 Physical Rev. B 10656 (1997) (“[1997-Bartkowski]”)
1087	F. Marques and J.J. Jasieniak, <i>Ionization Potential and Electron Attenuation Length of Titanium Dioxide Deposited by Atomic Layer Deposition Determined by Photoelectron Spectroscopy in Air</i> , 2017 Applied Surface Sci. 422 (June 5, 2017) (“[2017-Marques]”)
1088	Y. Chen, et al., <i>Ground State Structure and Physical Properties of Silicon Monoxide Sheet</i> , 527 Applied Surface Sci. 146759 (2020) (“[2020-Chen]”)
1089	Petition, <i>Samsung Electronics Co., Ltd. v. Acorn Semi, LLC</i> , IPR2020-01207, Paper 2 (P.T.A.B. June 29, 2020)
1090	Decision Granting Institution, <i>Samsung Electronics Co., Ltd. v. Acorn Semi, LLC</i> , IPR2020-01207, Paper 21 (P.T.A.B. Feb. 10, 2021)
1091	Final Written Decision, <i>Samsung Electronics Co., Ltd. v. Acorn Semi, LLC</i> , IPR2020-01207, Paper 49 (P.T.A.B. Feb. 9, 2022)
1092	Trial Transcript, <i>Acorn Semi, LLC v. Samsung Elecs. Co., Ltd.</i> , No. 2:19-cv-00347 (E.D. Tex. May 14, 2021)
1093	Final Judgment, <i>Acorn Semi, LLC v. Samsung Elecs. Co., Ltd.</i> , No. 2:19-cv-00347, ECF No. 379 (E.D. Tex. July 13, 2021)
1094	Z. Luo, <i>High-K Gate Dielectrics For Si CMOS Applications</i> , A Dissertation Presented To The Faculty Of The Graduate School of Yale University, Dec. 2003 (“2003-Luo”)
1095	Complaint, <i>Oak IP, LLC v. GlobalFoundries, Inc., and GlobalFoundries US Inc.</i> , No. 25-cv-00142-MN, ECF No. 1 (D. Del. Feb. 4, 2025)
1096	Petition, <i>Samsung Electronics Co., Ltd. v. Acorn Semi, LLC</i> , IPR2020-01282, Paper 2 (P.T.A.B. July 13, 2020)
1097	Final Written Decision, <i>Samsung Electronics Co., Ltd. v. Acorn Semi, LLC</i> , IPR2020-01282, Paper 56 (P.T.A.B. Feb. 9, 2022)
1098	Decision Granting Institution, <i>Samsung Electronics Co., Ltd. v. Acorn Semi, LLC</i> , IPR2020-01282, Paper 20 (P.T.A.B. Feb. 10, 2021)
1099	U.S. Patent No. 5,216,282 (“Cote”)

Exhibit	Description
1100	Markman Order, <i>Acorn Semi, LLC v. Samsung Elecs. Co., Ltd.</i> , No. 2:19-cv-00347, ECF No. 85 (E.D. Tex. Oct. 16, 2020)
1101	U.S. Patent No. 6,724,088 (“Jammy”)
1102	D. Brassard et al., <i>Compositional Effect on the Dielectric Properties of High- Titanium Silicate Thin Films Deposited by Means of a Cosputtering Process</i> , J. Vac. Sci. Tech. A 24, 600 (2006) (“2006-Brassard”)
1103	Stesmans et al., <i>Si dangling-bond-type defects at the interface of (100)Si with ultrathin SiOx, Al2O3, and ZrO2</i> , Applied Physics Letters 80(11):1957-59 (2002) (“Stesmans”)
1104	Order – Dismissed all claims, <i>Acorn Semi, LLC v. Samsung Elecs. Co., Ltd.</i> , No. 2:19-cv-00347, ECF No. 416 (E.D. Tex. Jan. 6, 2023)
1105	Certificate of Cancellation of Claims of U.S. Patent No. 10,090,395
1106	Acorn Semi, LLC, Disclaimer in U.S. Patent No. 10,090,395 under 37 C.F.R. 1.321(a), Claim 10 (Nov. 13, 2020)
1107	S. M. Sze, <i>Semiconductor Devices: Physics and Technology</i> , 2nd Ed. 2002 Textbook (“Sze”)
1108	Lucovsky et al, <i>Bonding Constraint-Induced Defect Formation at Si-Dielectric Interfaces and Internal Interfaces in Dual-Layer Gate Dielectrics</i> , 17 J. Vac. Sci. Tech. (Jul/Aug 1999) (“1999-Lucovsky”)
1109	GlobalFoundries waiver of service (Mar. 4, 2025)
1110	Groner et al, <i>Electrical Characterization of Thin Al2O3 Films Grown By Atomic Layer Deposition on Silicon and Various Metal Substrates</i> , 413 Thin Solid Films 186-197 (2002) (“2002-Groner”)
1111	Tsai et al, <i>Surface Preparation and Interfacial Stability of High-K Dielectrics Deposited by Atomic Layer Chemical Vapor Deposition</i> , 65 Microelectronic Eng’g 259-272 (2003) (“2002-Tsai”)
1112	Raider et al, <i>Oxide Growth on Etched Silicon in air at room Temperature</i> , J. Electrochem. Soc.: Solid-State Sci. & Tech. (Mar. 1975) (“1975-Raider”)
1113	Cerofolini et al, <i>Mechanisms and Kinetics of Room-Temperature Silicon Oxidation</i> , 216 J. Non-Crystalline Solids 140-147 (1997) (“1997-Cerofolini”)
1114	Mende et al, <i>Oxidation of Etched Silicon in Air at Room Temperature; Measurements With Ultrasoft X-Ray Photoelectron</i>

Exhibit	Description
	<i>Spectroscopy (ESCA) and Neutron Activation Analysis</i> , 128 Surface Sci. 169-175 (1983) (“1983-Mende”)
1115	Toshiba, <i>e-learning: Basics of Schottky Barrier Diodes</i> , Ch. 1 (2002), https://toshiba.semicon-storage.com/us/semiconductor/knowledge/e-learning/basics-of-schottky-barrier-diodes/chap1/chap1-1.html
1116	Final Written Decision, <i>Samsung Electronics Co., Ltd. v. Acorn Semi, LLC</i> , IPR2020-01183, Paper 52 (P.T.A.B. Feb. 9, 2022)
1117	TiO Melting Point
1118	TiO ₂ Melting Point
1119	Ti ₂ O ₃ Melting Point

All citations to specific pages of exhibits follow the pagination added to those exhibits per 37 C.F.R. § 42.63(d)(2)(i).

I. INTRODUCTION

GlobalFoundries U.S., Inc. and GlobalFoundries, Inc. (collectively, “Petitioners” or “GF”) request *inter partes* review of Claims 7, 11-14, and 17-30 (“the Challenged Claims”) of U.S. Patent No. 10,090,395 (Ex.1001, “the ’395 Patent”) assigned to Oak IP, LLC (“PO” or “Oak”). The ’395 Patent relates to metal-semiconductor junctions with an interface layer between the metal and the semiconductor. (Ex.1001, 1:31-35.) The ’395 Patent purports to claim a priority date of August 12, 2002 through a series of parent applications, the earliest of which issued as U.S. Patent No. 7,084,423. (Ex.1001, Cover, 1:8-27; Ex.1003.)¹

In 2020, Samsung Electronics Co., Ltd. (“Samsung”) challenged certain claims of the ’395 Patent in two prior petitions, in response to a Complaint filed in October 2019 by Acorn Semi, LLC (“Acorn”) in a district court. Petitioners have no connection with the prior petitions or the prior litigation. Oak filed a district court Complaint against Petitioners on February 4, 2025 and this is Petitioners’ first

¹ Upon issuance, the interface layer in Claims 1-10 and 15-16 comprised a *metal oxide* whereas the interface layer in Claims 11-14 and 17-28 comprised an *oxide of titanium*. The interface layer in Claims 29-30 did not recite either a metal oxide or an oxide of titanium.

petition challenging the '395 Patent claims.² As discussed below, the Petition presents grounds that were either not presented to the Board in prior petitions or not expressly considered by the Board in those petitions.

In the *first petition* (IPR2020-01207), filed on June 29, 2020, Samsung challenged claims 1-6, 8-12, and 14-16 of the '395 Patent based on U.S. Patent No. 7,176,483 (Ex.1021, "Grupp '483"). Samsung argued the claims at issue encompassed a "metal oxide" genus, but the genus lacked adequate written description support; as a result, Grupp '483—which issued in 2007 and has the same ancestor as the '395 Patent—qualified as prior art to the claims. Samsung also argued that the "oxide of titanium" genus lacked written description support for challenged Claims 11, 12, and 14. (Ex.1091, 27.) In the Final Written Decision issued on February 9, 2022, the Board concluded that Claims 1-6, 8-9, 15 and 16 were unpatentable, though Claims 11, 12 and 14 were not proven unpatentable. (Ex.1091, 50.)³ Though the Board concurred with Samsung that the genus of "metal oxide" lacked adequate written description support, the Board expressly stated that it did *"not consider the breadth challenge to a metal oxide comprising oxide of titanium*

² Oak asserts that it is the sole owner of the '395 Patent. (Ex.1095, ¶20.)

³ Acorn disclaimed Claim 10 of the '393 Patent. (Ex.1106.)

that Petitioner presented for the first time in its Reply.” (*Id.*, 28.)⁴ The petition did not challenge Claims 17-30.

In the *second petition* (IPR2020-01282), filed on July 13, 2020, Samsung challenged claims 1-6, 8-9, 11, 12, and 14-28 of the ’395 Patent based primarily on an article published by Goodnick (Ex.1025, “Goodnick”) and U.S. Patent No. 6,724,088 (Ex.1101, “Jammy”). In another Final Written Decision issued on February 9, 2022, the Board concluded that Claims 1-5 and 8-10 were unpatentable, though claims 6, 11, 12 and 14-28 were not proven unpatentable. (Ex.1097, 63.) Samsung did not rely upon Grupp ’483 in the second petition.

Among the Challenged Claims, the Petition challenges Claims 7, 11-14, 17-28 based on Grupp ’483. The *first petition* by Samsung that relies upon Grupp ’484 did not challenge Claims 7, 13, and 17-28 and the Board expressly stated that it did not consider Samsung’s evidence regarding Claims 11, 12, and 14. Thus, the Board has not applied Grupp ’483 to these claims. The Petition also challenges Claims 29 and 30 based on Jammy. Though the *second petition* relied upon Jammy, that petition did not challenge Claims 29 and 30. Thus, the Board has not considered grounds raised in this Petition for the Challenged Claims.

⁴ Emphasis added unless noted otherwise.

The Challenged Claims requiring an “oxide of titanium” (i.e., Claims 11-14 and 17-28) are not entitled to the 2002 priority date because the specification does not provide adequate written description support to the “oxide of titanium” genus. Both Oak and Acorn (the prior patent owner) have asserted in district court that the “oxide of titanium” genus includes ternary compounds, such as, titanium silicon oxide (TiSiO_x). (Ex.1095, ¶¶52-54, 68, 78.) Though the Challenged Claims requiring an “oxide of titanium” purportedly cover any binary or ternary compound containing oxygen and titanium (*id.*), the specification discloses **only one** example of such a compound: titanium dioxide (TiO_2), which is binary. The single disclosed species— TiO_2 —is not representative of the entire “oxide of titanium” genus and does not describe features common to all members of the claimed genus. Thus, the “oxide of titanium” limitation lacks adequate written description support in the specification of the ’395 Patent.

Not all of the ancestor applications of the ’395 Patent describe the “oxide of titanium” genus. Indeed, the first time the patentee even arguably described an “oxide of titanium” in an interface layer was in the originally filed claims of U.S. Patent App. No. 15/048,877—which was not filed until February 19, 2016. (Ex.1014, 61.) As a result, no Challenged Claim requiring an “oxide of titanium” can possibly obtain a priority date earlier than February 19, 2016. Thus, Grupp ’483 qualifies as prior art to Claims 11-14 and 17-28.

Claim 7 (which depends from Claim 1) does not narrow that genus of “metal oxide” further, and the Board has previously found that Claim 1 is not entitled to a priority date earlier than February 7, 2011. (Ex.1091, 26.) Thus, Claim 7 is also not entitled to a priority date earlier than February 7, 2011, and Grupp ’483 qualifies as prior art to Claim 7.

Claims 29 and 30 require neither a metal oxide nor an oxide of titanium. Jammy—filed on April 20, 1999—qualifies as prior art to those claims.

As shown herein and as further explained in the declaration of Dr. E. Fred Schubert, an expert in metal-semiconductor junctions (Ex.1022, ¶¶8-21), Grupp ’483 anticipates every Challenged Claim except claims 29 and 30, but Jammy alone renders these two claims obvious.

II. MANDATORY NOTICES

A. Real Parties-in-Interest (37 C.F.R. § 42.8(b)(1))

Petitioners identify the following as the real parties-in-interest:

GLOBALFOUNDRIES Inc. and GLOBALFOUNDRIES U.S., Inc.

B. Related Matters (37 C.F.R. § 42.8(b)(2))

1. Judicial Matters

The following judicial matters may affect or be affected by this proceeding: *Oak IP, LLC v. GlobalFoundries U.S., Inc. and GlobalFoundries, Inc.*, Civil Action No. 25-142 (MN) (D. Del.) (“the Oak Litigation”), in which PO filed a complaint alleging that Petitioners and their real parties-in-interest infringe the ’395 Patent

(Ex.1095, ¶¶1-2). Oak first served the complaint on GlobalFoundries U.S., Inc. on February 4, 2025, (Ex.1095), and GlobalFoundries, Inc., waived service on March 4, 2025. (Ex.1109.)

2. Administrative Matters

Petitioners will be filing one or more petitions for *inter partes* review against the following patents related to the '395 Patent: U.S. Patent Nos. 9,905,691 and 10,937,880. Those proceedings may affect or be affected by this proceeding. Further, Oak has asserted those two patents against Petitioners. (Ex.1095 ¶¶1-2.)

C. Lead and Back-Up Counsel:

Lead Counsel	Back-Up Counsel
Scott C. Weidenfeller (Reg. No. 54,531) sweidenfeller@cov.com <u>Postal and Hand-Delivery Address:</u> Covington & Burling LLP One CityCenter, 850 Tenth Street NW Washington, DC 20001 T: (202) 662-5923; F: (202) 778-5923	Anupam Sharma (Reg. No. 55,609) asharma@cov.com <u>Postal and Hand-Delivery Address:</u> Covington & Burling LLP 3000 El Camino Real 5 Palo Alto Square Palo Alto, California 94306 T: (650) 632-4709; F: (650) 632-4809 Peter P. Chen (Reg. No. 39,631) pchen@cov.com <u>Postal and Hand-Delivery Address:</u> Covington & Burling LLP 3000 El Camino Real 5 Palo Alto Square Palo Alto, California 94306 T: (650) 632-4720; F: (650) 632-4820
	Dr. W. Kiersten Choi (Reg. No. 73,012) wchoi@cov.com

	<u>Postal and Hand-Delivery Address:</u> Covington & Burling LLP One CityCenter, 850 Tenth Street NW Washington, DC 20001 T: (202) 662-5240; F: (202) 778-5240
--	--

Pursuant to 37 C.F.R. § 42.10(b), Petitioners have filed a power of attorney with the above designation of counsel.

D. Service Information:

Please address correspondence to counsel at the address above. Petitioners consent to electronic service to: GF-Oak-IPR@cov.com and the email addresses listed above. Service information is provided in the designation of counsel above.

III. PAYMENT OF FEES

This Petition is accompanied by the fees set forth in 37 C.F.R. § 42.15(a). Please charge or credit Deposit Account No. 60-3160 with any shortage or overpayment of fees associated with this Petition and any other fees incurred by Petitioners.

IV. GROUNDS FOR STANDING

Petitioners certify that the '395 Patent is available for *inter partes* review. Petitioners further certify that neither Petitioners nor any real party-in-interest or privy is estopped or barred from requesting *inter partes* review of the challenged claims on the grounds identified in this Petition.

V. PRECISE RELIEF REQUESTED AND GROUNDS RAISED

Petitioners request *inter partes* review and cancellation of Claims 7, 11-14, and 17-30 of the '395 Patent.

A. Identification of Prior Art

1. Grupp '483 (Ex.1021)

As discussed in detail below in **Section X**, Challenged Claims requiring an oxide of titanium (i.e., Claims 11-14 and 17-28) are not entitled to a priority date earlier than February 19, 2016, the filing date of U.S. Patent App. No. 15/048,877. Claim 7 is not entitled to a priority date earlier than February 7, 2011, the filing date of U.S. Patent App. No. 13/022,522. Thus, U.S. Patent No. 7,176,483 (Ex.1021, “Grupp '483”), issued on February 13, 2007, qualifies as prior art to Claims 7, 11-14 and 17-28 under at least pre-AIA 35 U.S.C. § 102(b).⁵

2. Jammy (Ex.1101)

Claims 29 and 30 require neither a metal oxide nor an oxide of titanium. Thus, U.S. Patent No. 6,724,088 (Ex.1101, “Jammy”), filed on April 20, 1999—qualifies as prior art to Claims 29 and 30 under at least pre-AIA 35 U.S.C. § 102(e).

⁵ If Oak argues that the '395 Patent is governed by the AIA, Grupp '483 qualifies as prior art under AIA 35 U.S.C. § 102(a)(1).

B. Statutory Grounds of Unpatentability

Ground 1: Grupp '483 anticipates Claims 7, 11-14, and 17-28 under at least pre-AIA 35 U.S.C. § 102(b) or under AIA 35 U.S.C. § 102(a)(1).

Ground 2: Jammy renders obvious Claims 29 and 30 under at least pre-AIA 35 U.S.C. § 103(a).

VI. OVERVIEW OF PRIOR ART

A. Grupp '483

Grupp '483 is a continuation-in-part of an August 2002 application that issued as U.S. Patent No. 7,084,423. (Ex.1021, Cover, 1:8-19.) The '395 Patent purports to claim priority to that same August 2002 application through a chain of ancestor applications. (Ex.1001, Cover, 1:8-29.) Thus, Grupp '483 and the '395 Patent and its ancestor applications have significantly overlapping disclosures. Unsurprisingly, Grupp '483 anticipates Claims 7, 11-14, and 17-28. (Ex.1022, ¶¶168-174.)

B. Jammy

Jammy generally describes a MOSFET (metal oxide semiconductor field effect transistor) that incorporates quantum conductive barrier layers 56 and 58 between conductive studs 52 and 54 and shallow source/drain diffusions (doped regions) 42 and 44 in a silicon substrate, as depicted below:

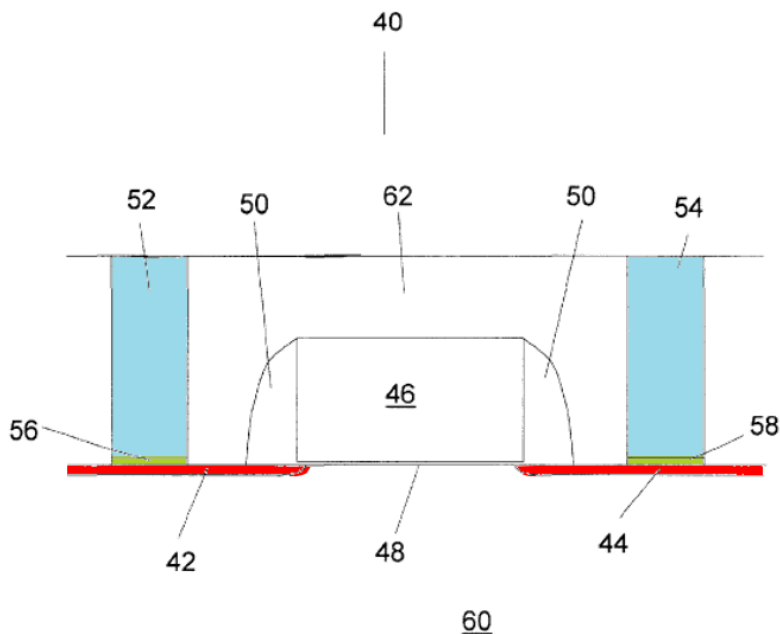


Figure 1

(Ex.1101, Fig. 1 (annotations added), 2:42-53, 3:16-22.) Jammy renders obvious Claims 29 and 30 of the '395 Patent. (Ex.1022, ¶¶175-180.)

VII. OVERVIEW OF THE '395 PATENT

A. Technical Background

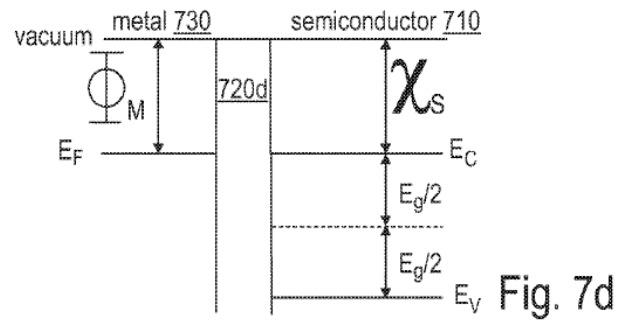
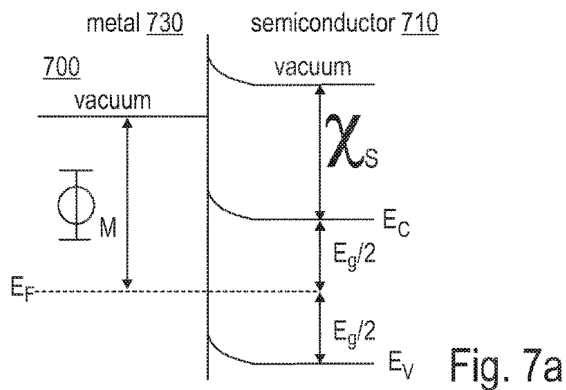
Metal-semiconductor junctions are basic electronic components. (Ex.1022, ¶38; Ex.1001, 1:39-40.) Those junctions are generally characterized by a barrier to the movement of charge carriers at the interface between the metal and the semiconductor, called a Schottky barrier. (Ex.1023, 1; Ex.1001, 1:52-54; Ex.1022,

¶¶39-40.) The barrier's width and height each affect the junction's specific contact resistance.⁶ (Ex.1024, 545-546; Ex.1022, ¶¶41-47.)

The Schottky barrier height of a metal-semiconductor junction can become fixed at a particular height in a phenomenon known as Fermi-level pinning. (Ex.1001, 2:10-67, 5:35-38, 7:55-59; Ex.1022, ¶¶48-51.) Electron states can cause the Fermi level to become pinned between the semiconductor's conduction and valence bands, typically at or near the midgap.⁷ (Ex.1001, 2:41-3:9, 16:66-17:1; Ex.1022, ¶52.) Fig. 7a depicts that the pinned Fermi level E_F in the metal-semiconductor junction is not aligned with the conduction band edge E_C of the semiconductor at the interface:

⁶ Height of the barrier represents the energy an electron needs to overcome to move from the semiconductor to metal or vice versa, and width of the barrier is the width of the depletion region created when the electrons deplete (or move) from the semiconductor and transition to metal. (Ex.1022, ¶125.)

⁷ Energy states refers to states, such as Bardeen states that are created by dangling bonds at the semiconductor surface and metal-induced gap states (MIGS) that are energy states in the bandgap of the semiconductor that become populated due to the proximity of the metal. (Ex.1022, ¶¶45-47.)



(Ex.1001, Figs. 7a and 7d, 16:65-17:1, 17:13-25; Ex.1022, ¶53.)

However, as Fig. 7d depicts, “when the interface layer 720d is sufficient to both eliminate or reduce the effect of MIGS and to passivate the semiconductor surface, we see the Fermi level of the metal aligning with the conduction band of the semiconductor” and “vacuum level is now continuous as there is no charged dipole at the interface.” (*Id.*, 17:13-25; Ex.1022, ¶53.)

“The importance of the barrier height at a metal-semiconductor interface is that it determines the electrical properties of the junction. Thus, if one were able to control or adjust the barrier height of a metal-semiconductor junction, one could produce electrical devices of desired characteristics.” (Ex.1001, 3:10-14.) According to the ’395 Patent, depinning a Fermi level is one technique for accomplishing that. (*Id.*, 16:36-57, Ex.1022, ¶¶54-55.)

But even before the earliest alleged priority date of August 2002 of the Challenged Claims, techniques for depinning a Fermi level and controlling barrier height were well-known. (Ex.1022, ¶¶56-57.) Indeed, the prior art was replete with

examples of interface layers that depin a Fermi level by passivating the semiconductor surface (thereby satisfying dangling bonds and reducing Bardeen states) and reducing the effects of metal-induced gap states (MIGS), including the examples described in the Goodnick, Rhoderick, and Sobolewski references. (Ex.1022, ¶¶58-60; Ex.1025, 949; Ex.1023, 3; Ex.1026, 971.) It was similarly well-known that an interfacial oxide could reduce the barrier height of a metal-semiconductor junction. (Ex.1022, ¶¶61-63; Ex.1027, 1:43-50; Ex.1028, 897.) Likewise, prior art spanning three decades taught that an interface layer could reduce the specific contact resistance of a metal-semiconductor junction: for example, the 1976 Schroen patent, the 1989 Kim patent, and the 1999 Iwaguro patent application publication. (Ex.1022, ¶¶64-68; Ex.1029, Abstract; Ex.1030, 4:63-5:1, 5:27-30; Ex.1032, [0005]-[0006], [0012]-[0014].)

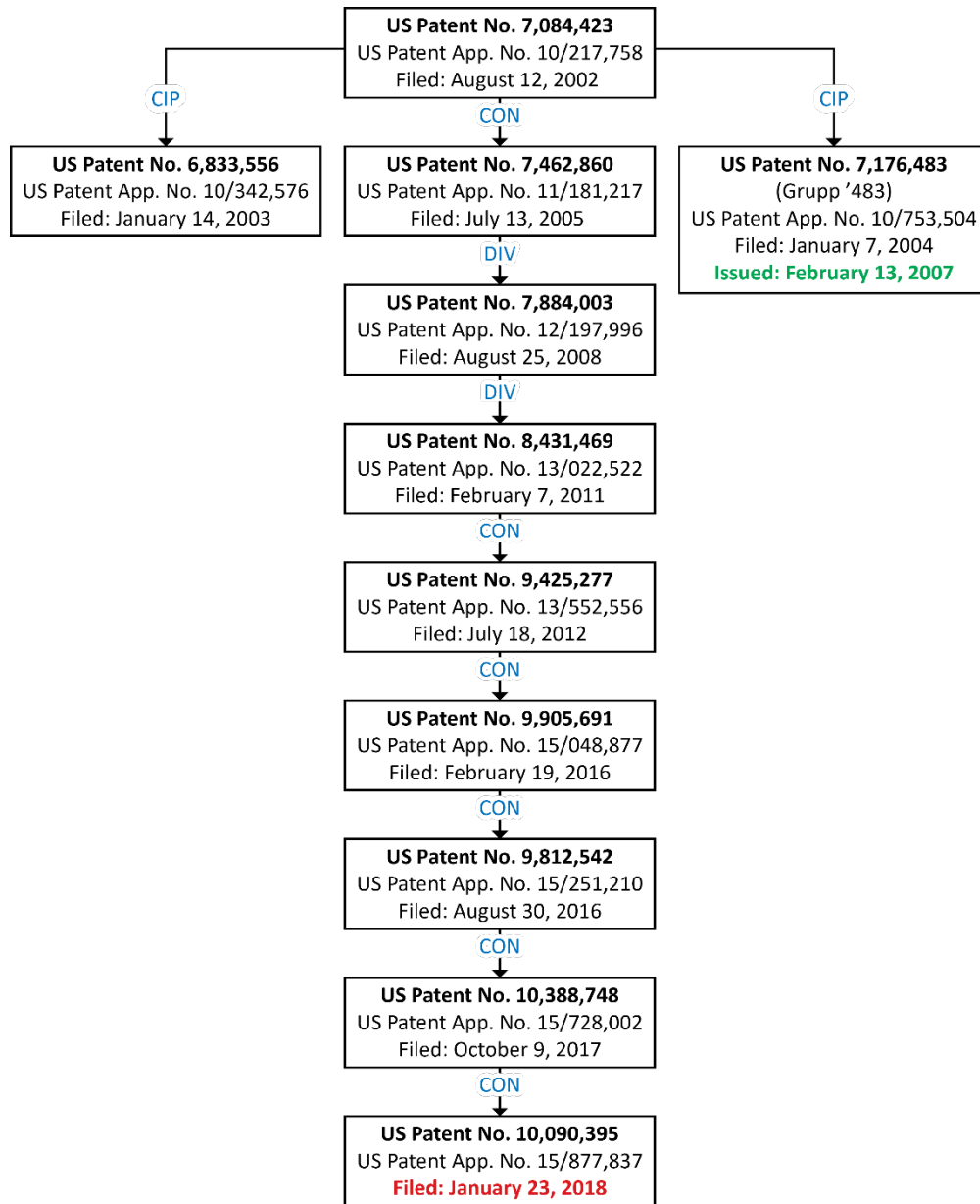
B. The Purported Invention of the '395 Patent

The purported invention of the '395 Patent, like the prior art, involves providing an interface layer between the metal and the semiconductor in a metal-semiconductor junction. (Ex.1001, 1:31-35.)

C. Prosecution History

The '395 Patent began as U.S. Patent App. No. 15/877,837 (“the '837 Application,” filed on January 23, 2018. (Ex.1020, 3-49.) The '395 Patent purports

to claim a priority date of August 12, 2002 through a series of parent applications, as shown in the partial family tree below:



(Ex.1005, Cover; Ex.1020, 5; Ex.1021, Cover, 1:8-19.)

Each challenged claim was among the originally filed claims of the '837 Application. (Ex.1020, 39-42.) In the first Office action, the Examiner concluded

that the '837 Application, styled as a continuation, was “actually a Continuation-In-Part.” (*Id.*, 121.) According to the Examiner, “[a]ll of the independent claims recite either a semiconductor oxide or oxide of the semiconductor and a metal oxide or oxide of titanium in the interface layer, ***the pairing*** of which is not found or contemplated in the parent applications.” (Ex.1020, 121.) The Examiner then rejected every challenged claim over U.S. Patent App. Pub. No. 2014/0117465 (“Huang”), either by itself or in combination with another reference. (*Id.*, 122-129; Ex.1037.)

In response, the applicants contended that the parent applications describe an interface layer that includes a passivation layer and a separation layer, and that the parent applications describe a titanium dioxide separation layer. (Ex.1020, 162-163.) According to the applicants, the pending claims were entitled to a priority date of August 12, 2002, disqualifying Huang as prior art. (*Id.*)

The Examiner allowed the claims on the next action. (*Id.*, 174.) But the Examiner’s statements on the reasons for allowance did not actually ascribe any specific priority date to the challenged claims. (*Id.*) The '837 Application then issued as the '395 Patent. (*Id.*, 196.)

D. Prior Litigation and IPR Petitions

1. District Court

On October 23, 2019, Acorn filed a Complaint in the Eastern District of Texas against Samsung, alleging infringement of several patents, including the '395 Patent. (Ex.1038) (“the Acorn Litigation”). It appears that the parties eventually settled the dispute in January 2023. (Ex.1104.)

2. PTAB

On June 29, 2020, Samsung filed a petition for an *inter partes* review of claims 1-6, 8-12, and 14-16 of the '395 patent. (Ex.1089.) On November 13, 2020, Acorn disclaimed Claim 10. (Ex.1106.) On February 9, 2022, the Board issued a final written decision determining that claims 1-6, 8-9, 15 and 16 were unpatentable. (Ex.1091, 50.) The Board held, *inter alia*, that Acorn was not entitled to the benefit of any pre-2011 priority applications for claims 1-6, 8-9, 15, and 16 (i.e., claims that require an interface layer comprising a “metal oxide”), and Grupp '483 was prior art for those claims. (*Id.*, 26.) The petition did not challenge Claims 17-30 and the Board did not consider priority arguments regarding Claims 11, 12 and 14, noting that the arguments were not present in the petition. (*Id.*, 28.)

On July 13, 2020, Samsung filed another petition for *inter partes* review of claims 1-6, 8-12, and 14-28 of the '395 patent based primarily on Goodnick (Ex.1025) and Jammy (Ex.1101). (Ex.1096.) On February 9, 2022, the Board issued a final written decision determining that Claims 1-3 and 8-9 were unpatentable under

35 U.S.C. § 102(b) and Claims 4-5 were unpatentable under 35 U.S.C. § 103(a).
(Ex.1097, 64.)

VIII. CLAIM CONSTRUCTION

For petitions filed after November 13, 2018, the Board “constru[es] the claim in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent.” 37 C.F.R. § 42.100(b); *see also Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (en banc). The Board need only construe claim terms to the extent necessary to resolve a controversy. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (citing *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999)).

The district court in the Eastern District of Texas issued a *Markman* order on October 16, 2020, construing several terms from the ’395 Patent, and the pertinent constructions are listed below:

Term	Claims	Construction
“a semiconductor device”	23-28	The preamble is not limiting
“interface layer”	1-30	Plain and ordinary meaning
“said interface layer comprising an oxide of	17-28	“said interface layer comprising a layer of an oxide of titanium and a

Term	Claims	Construction
titanium and an oxide of the semiconductor”		distinct layer of an oxide of the semiconductor region”

(Ex.1100, 14, 27-29.)

The Petitioners have applied the constructions enumerated above. The Board need not expressly construe any term at this stage.⁸

IX. LEVEL OF ORDINARY SKILL

Any of the following combinations of education and experience would have qualified someone as an ordinarily skilled artisan in the field of the ’395 Patent:

- a Ph.D. in electrical engineering, physics, materials science, or chemical engineering, with two years of practical experience with semiconductor research and design;

⁸ Petitioners reserve all rights to raise claim construction arguments and other arguments in the Oak Litigation or other proceedings involving the ’395 Patent. For example, Petitioners have not raised all of their challenges to the ’395 Patent here, including invalidity under 35 U.S.C. § 112. Further, comparing the claims to the accused products in the Oak Litigation may raise controversies that require claim construction in that litigation, but not here.

- a Master's degree in electrical engineering, physics, materials science, or chemical engineering, with four years of practical experience with semiconductor research and design; or
- a Bachelor's degree in electrical engineering, physics, materials science, or chemical engineering, with six to eight years of practical experience with semiconductor research and design.

(Ex.1022, ¶¶78-83.) Further, additional education could make up for less practical experience, and vice versa. (*Id.*) The same level of ordinary skill would have been applicable in August 2002, February 2011, or February 2016. (*Id.*, ¶84.) The Board applied the above description of the level of skill in its final written decisions pertaining to the '395 Patent. (Ex.1091, 9; Ex.1097, 10.)

X. PRIORITY DATE OF THE CHALLENGED CLAIMS

The '395 Patent purports to claim priority to August 12, 2002, the filing date of the application that issued as U.S. Patent No. 7,084,423. (Ex.1001, Cover, 1:8-27; Ex.1003, Cover.) For the Challenged Claims to receive the benefit of the priority of that August 12, 2002 filing date, the patentee must show that every application in the priority chain leading to the application that issued as the '395 Patent must support every limitation of the challenged claims under 35 U.S.C. § 112 ¶1. *In re NTP, Inc.*, 654 F.3d 1268, 1277 (Fed. Cir. 2011). Thus, every parent application of

the '395 Patent must both enable and describe every limitation of every challenged claim. *See id.*; *Fiers v. Revel*, 984 F.2d 1164, 1169-70 (Fed. Cir. 1993).

A. Claims 11-14 and 17-28

Claims 11-14 and 17-28 have at least one limitation that the parent applications fail to support: *an oxide of titanium*. The specifications and figures in the parent applications are substantively identical to the '395 Patent, including in their incorporation by reference of U.S. Patent No. 6,833,556. (Ex.1005.) Thus, if the limitation lacks support in the specification of the '395 Patent, it also lacks support in the disclosures of the parent applications, and vice versa. (Ex.1002, 5-52; Ex.1003; Ex.1006, 3-42; Ex.1007; Ex.1008, 8-48; Ex.1009; Ex.1010, 14-51; Ex.1011; Ex.1012, 6-46; Ex.1013; Ex.1014, 12-17, 35-65; Ex.1015; Ex.1016, 12-48; Ex.1017; Ex.1018, 51-87; Ex.1019.)

The only differences among the parent applications and the '395 Patent are their respective abstracts and claims. But, even those abstracts and claims cannot provide the challenged claims with any priority date earlier than February 19, 2016. In particular, the patentee did not even arguably disclose a generic “oxide of titanium” limitation as part of an “interface layer” until February 19, 2016, in the originally filed claims of U.S. Patent App. No. 15/048,877. (Ex.1014, 61; Ex.1022, ¶¶88-98.) Thus, the priority date of Challenged Claims requiring an “oxide of titanium” (i.e., Claims 11-14 and 17-28) is no earlier than February 19, 2016.

B. Claim 7

The Board has ruled that Claims 1-6, 8-10, 15, and 16 of the '395 Patent are not entitled to a priority date earlier than February 7, 2011 because the earlier filed parent applications do not describe the “metal oxide” genus. (Ex.1091, 26.) Because Claim 7 (which depends from Claim 1) does not narrow that genus further and merely requires that the metal electrical contact comprise an alloy of a metal, the priority date of Claim 7 can be no earlier than February 7, 2011.

C. Claims 29 and 30

These claims require an interface layer but do not require the interface layer to have a “metal oxide” or an “oxide of titanium.” Thus, the priority date for the claims can be no earlier than August 12, 2002, which is the filing date of U.S. Patent App. No. 10/217,758. (Ex. 1002.)

XI. '395 PATENT AND ITS PARENT APPLICATIONS DO NOT ADEQUATELY DESCRIBE THE GENUS OF “OXIDE OF TITANIUM”

A. Genus of “oxide of titanium” is extremely broad

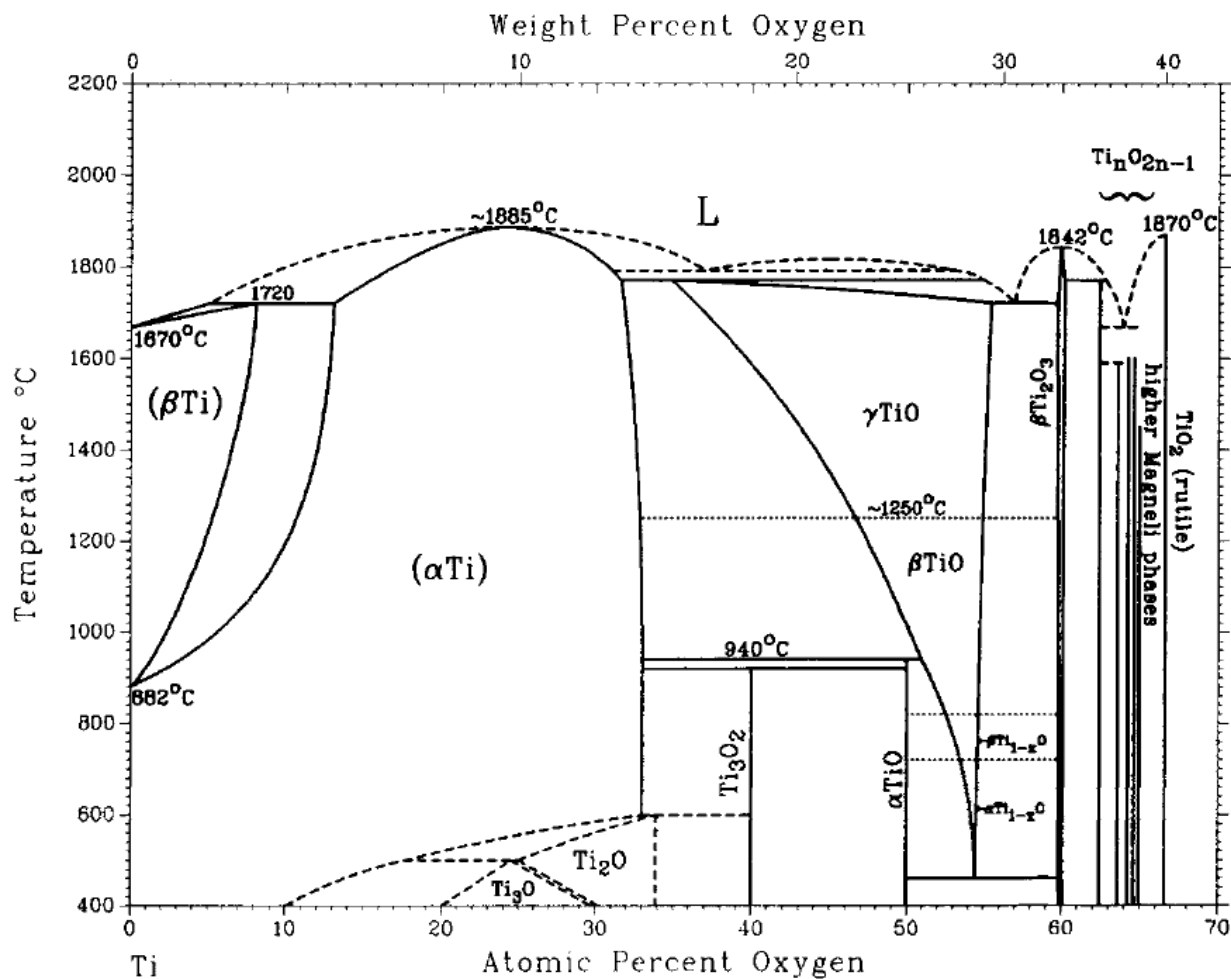
The genus of “oxide of titanium” is broad and is not adequately described by disclosure of a single species, TiO_2 . The genus encompasses (i) numerous binary compounds (compounds composed of two elements) composed of varying ratios of titanium and oxygen and (ii) numerous ternary compounds (compounds composed of three elements) composed of titanium, oxygen, and one other element. (Ex.1022, ¶¶99-103.) These binary and ternary compounds have drastically diverse physical,

structural, and electrical properties that are vastly different than the properties of TiO_2 . (Ex.1022, ¶¶108-167.) Thus, Challenged Claims requiring an “oxide of titanium” *cannot* obtain a priority date earlier than February 19, 2016 because the specification fails to provide adequate written description support to the entire genus. *See In re NTP*, 654 F.3d at 1276-77. (Ex.1022, ¶¶168-170.)

1. Genus of “oxide of titanium” includes numerous binary compounds composed of oxygen and titanium

Like generic metal oxides, there are numerous oxides of titanium, yet the Priority Applications disclose only *one*:⁹ TiO_2 . (Ex.1001, 18:6-8; Ex.1022, ¶¶88-98.) As shown below, some (but not all) titanium oxide species include TiO , Ti_2O , Ti_3O , TiO_2 , Ti_2O_3 , Ti_3O_5 , and Ti_4O_7 , among others. (Ex.1022, ¶¶99-100.)

⁹ Indeed, when deposed during the earlier IPR proceedings, Acorn’s expert could not even identify all of the titanium oxide species. Ex.1048, 114:10-18 (“Q. Dr. Kuhn, what are the different species in the titanium oxide genus? A. ... I don’t know how many chemical compounds exist within the Ti oxide family.”).



(Ex.1056, Figure 1; Ex.1022, ¶100.)

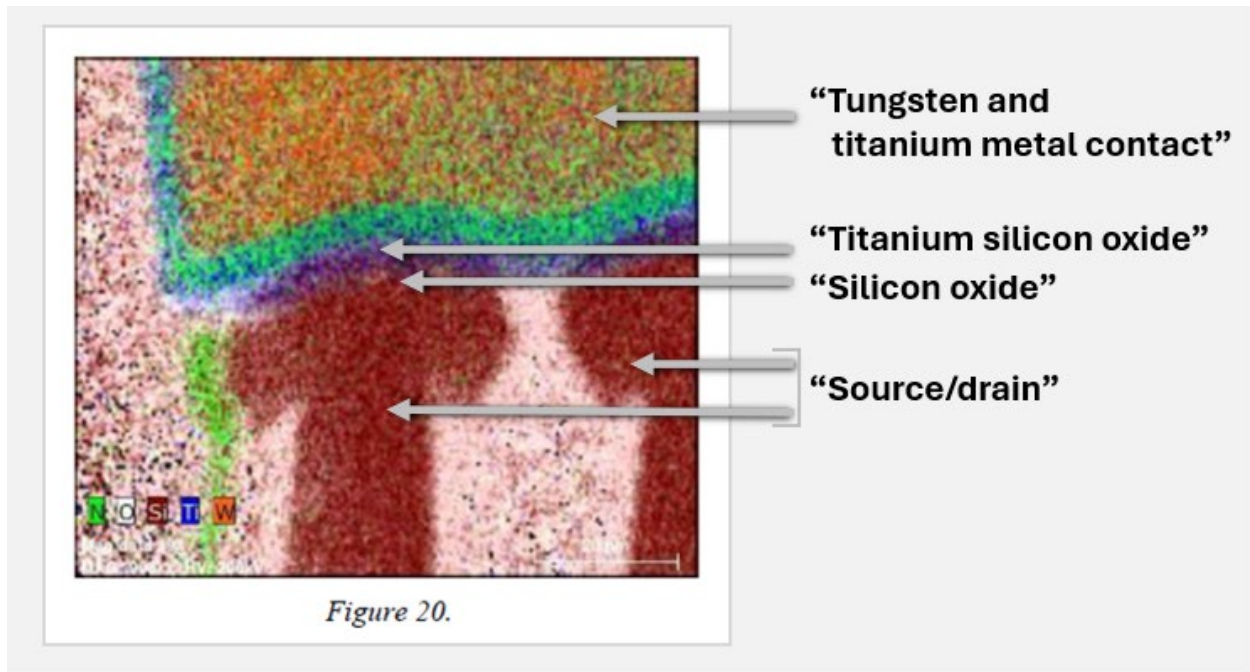
Moreover, in the semiconductor industry, titanium oxides are not limited to the equilibrium compounds discussed above; they can also include non-equilibrium compounds. (Ex.1048, 50:25-51:13; Ex.1022, ¶101.) In other words, a large number of different types of oxide of titanium species can be used in semiconductor devices. (Ex.1022, ¶101.)

2. Genus of “oxide of titanium” includes numerous ternary compounds composed of oxygen, titanium, and another element

Ternary compounds are three-element compounds that include titanium, oxygen, and another element. (Ex.1022, ¶¶102-103.) There may be at least ten to twenty such compounds with different characteristics making them suitable for multiple applications. (*Id.*) (listing ternary compounds comprising titanium, oxygen and one of the following: nitrogen, carbon, germanium, chromium, strontium, aluminum, barium, magnesium, calcium, and lithium.)

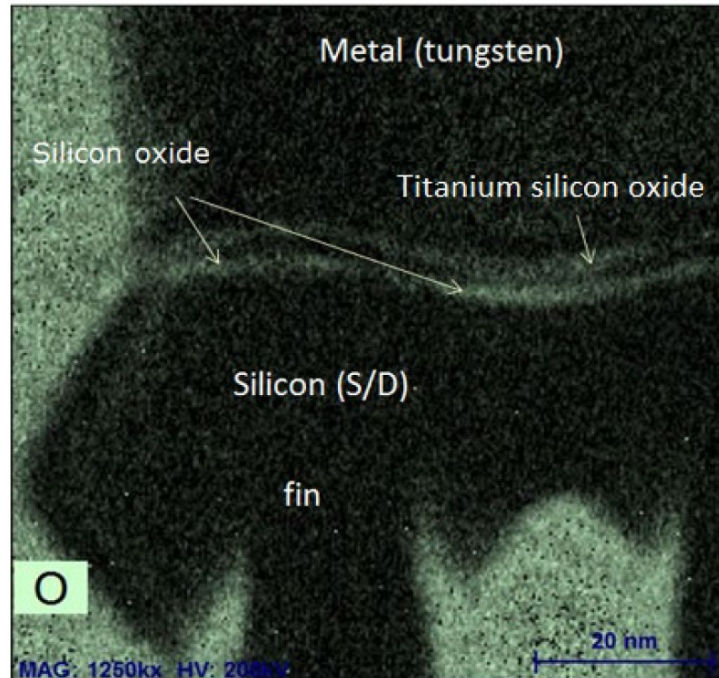
a) Oak argues that “oxide of titanium” includes ternary compounds composed of oxygen, titanium, and silicon

In the Oak Litigation, Oak contends that the genus of “oxide of titanium” includes “titanium silicon oxide.” (Ex.1095, ¶¶52-54, 68, 78) In the Complaint, with respect to the “interface layer” limitation of Claim 17 of the ’395 Patent that requires an *oxide of titanium*, Oak alleges that each product of the Petitioners “comprise[s] an *interface layer* of *titanium silicon oxide* and silicon dioxide.” (*Id.* ¶68.) Specifically, Oak alleges that in “the microscopic image . . . of a chip” fabricated by the Petitioners, “the *titanium silicon oxide* and silicon oxide interface layer can be seen in purple and pink (or maroon-white) between the tungsten and titanium nitride metal contact and the silicon semiconductor source/drain.” (*Id.*)



(Ex.1095, 29, Fig. 20 (annotated).) Thus, Oak asserts that “oxide of titanium” genus is not limited to binary compounds but also includes ternary compounds that include titanium, silicon, and oxygen.

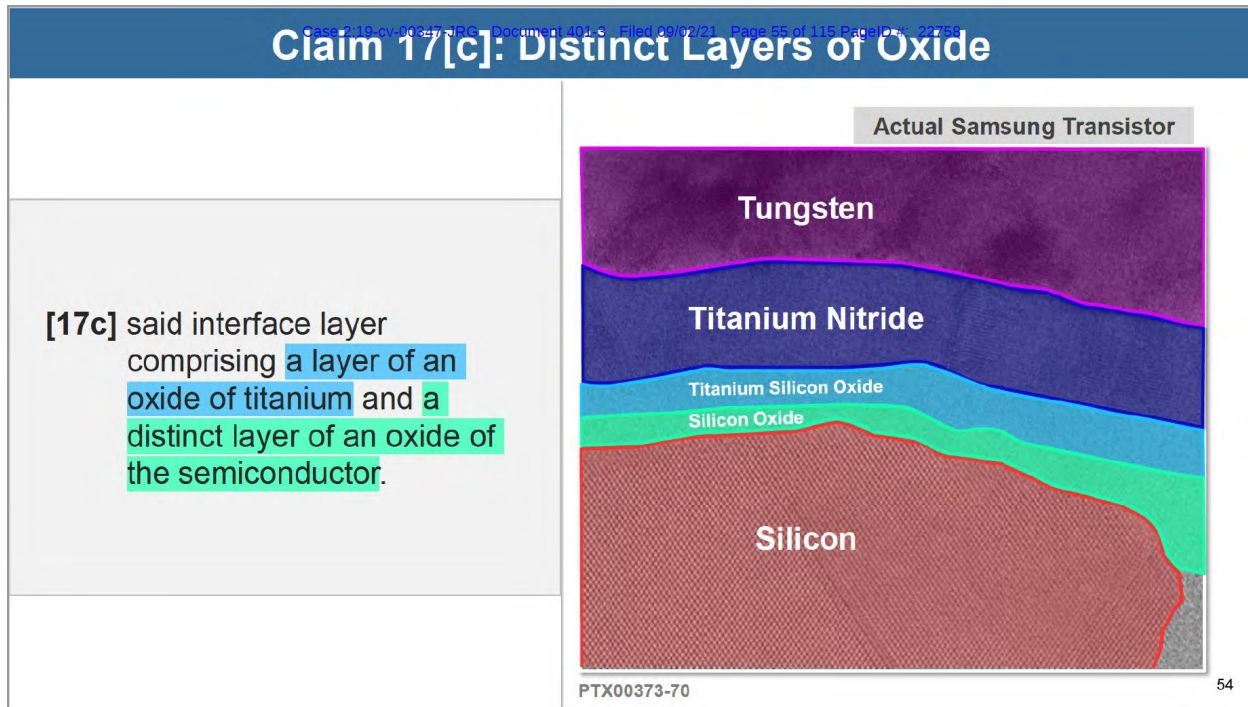
Likewise, in the Acorn Litigation, Acorn expressly interpreted the genus of “oxide of titanium” to encompass ternary compounds. Referring to the image below, Acorn argued that the accused products infringe Claim 17 of the '395 Patent because “the accused interface layer includes sublayers of *titanium silicon oxide, which comprises an oxide of titanium*, and silicon oxide, which is an oxide of silicon.” (Ex.1042, 25.)



Samsung 14nm LPE - Exynos 7420 (Galaxy S6)

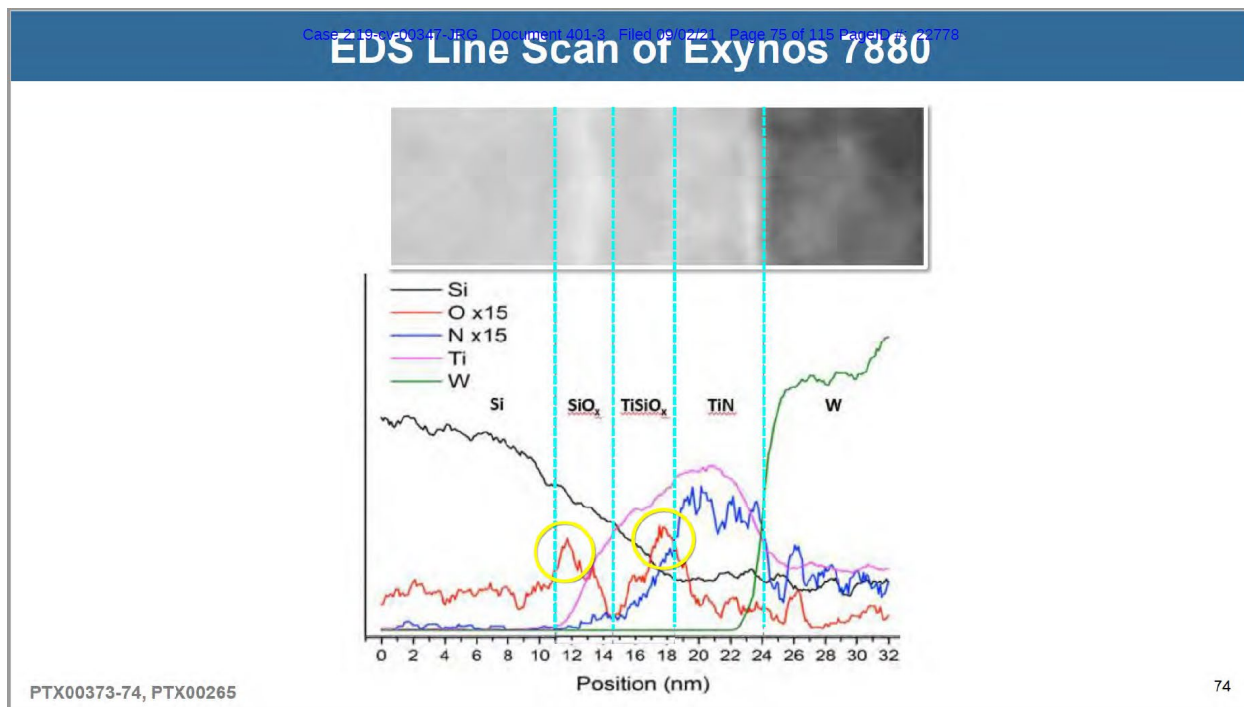
(Ex.1042, 23-24.)

At trial in the Acorn Litigation, Acorn explicitly argued that the “oxide of titanium” genus includes ternary compounds that contain silicon in addition to oxygen and titanium. During his testimony at trial, Acorn’s expert, Dr. Piner, relied upon the demonstrative below to argue that the “layer of an oxide of titanium” present in Limitation [c] of Claim 17 corresponds to the “Titanium Silicon Oxide” layer in the accused products:



(Ex.1044, 55.) When discussing the demonstrative slide above, Dr. Piner testified the term “a layer of an oxide of titanium” corresponds to the layer of “Titanium Silicon Oxide” in blue. (Ex.1092, 476-77) (“And so the interface layer needs to include a *layer of an oxide of titanium*, which I highlighted in the light blue here to correspond to what I’m showing in the image as *titanium silicon oxide*.”)

Acorn’s expert, Dr. Piner, did not limit the scope to a particular composition of titanium silicon oxide. Through the demonstrative slide below, Dr. Piner equated “oxide of titanium” to $TiSiO_x$, a compound of oxygen, titanium, and silicon in which the amount of oxygen can be arbitrary:



(Ex.1044, 75.) In other words, Acorn argued to the jury that the “oxide of titanium” includes all compounds of titanium, silicon, and oxygen irrespective of the amount of oxygen content. (Ex.1043, 23) (“[Samsung’s] argument is based on the idea that an oxide of titanium requires 33% oxygen, while an oxide of silicon requires 50% oxygen. . . . [Acorn’s expert] never agreed with either point, and [Samsung’s expert’s] testimony on these points was conclusory, at best. There was certainly not anything at trial *requiring* the jury to believe in Samsung’s claimed percentage requirements.”) (emphasis in original) (internal citations omitted). Acorn also argued that a compound containing “more than mere trace amounts” of oxygen, and as little as 5% or 15%, meets the “oxide of titanium” limitation. (*Id.* at 23) (“[Samsung’s expert’s] charts *did* show peaks of 5% and 15% oxygen at the accused

interface layer, which are more than mere trace amounts.”) (emphasis in original). During post-trial phase, while relying upon the above demonstrative, (Ex.1044, 75), Acorn did not limit ***TiSiO_x*** to a particular level of oxygen; instead it asserted that “Dr. Piner had identified the layer of silicon oxide and a ***layer of titanium silicon oxide***.” (Ex.1043, 5).

Relying upon the testimony of Dr. Piner, the jury found that Samsung infringes Claim 17 of the ’395 Patent. (Ex.1045, 4.) The District Court entered a final judgment shortly thereafter noting, *inter alia*, that Samsung infringed Claim 17 of the ’395 Patent. (Ex.1093, 2.)

b) Oak is estopped from arguing that ternary compounds containing titanium, silicon, and oxygen do not fall within the ambit of “oxide of titanium”

By virtue of Acorn’s infringement allegations during the Acorn Litigation regarding the scope of the “oxide of titanium” genus, the doctrine of judicial estoppel now estops Oak from arguing a narrower scope of that genus. As the present assignee of the ’395 Patent, Oak is bound by the acts of Acorn, the previous assignee of that patent. *See Worely v Loker Tobacco Co.*, 104 U.S. 340, 344 (1881) (“[T]he assignee of a patent right takes it subject to the legal consequences of the previous acts of the patentee.”); *In re Galaz*, 841 F.3d 316, 326 (5th Cir. 2016) (“Because Galaz is Vernon’s successor-in-interest, [Galaz] inherits the positions that [Vernon] has taken throughout the litigation. [Galaz] cannot now contend that Oshita has an ownership

interest in WSG, because that position is plainly inconsistent with Vernon’s prior position.”); *Adelphia Recovery Tr. v. Goldman, Sachs & Co.*, 748 F.3d 110, 120 (2d Cir. 2014) (finding appellants judicially estopped by actions of predecessors in interest); *see also Int’l Nutrition Co. v. Horphag Rsch., Ltd.*, 220 F.3d 1325, 1329 (Fed. Cir. 2000) (“[A] judgment with respect to a particular property interest may be binding on a third party based on a transfer of the property in issue to the third party after judgment.”).

The doctrine of judicial estoppel prevents a party who relied on one argument to prevail in a legal proceeding from advancing a contradictory argument in another proceeding. *See New Hampshire v. Maine*, 532 U.S. 742, 749 (2001). The doctrine’s purpose is “to protect the integrity of the judicial process by prohibiting parties from deliberately changing positions according to the exigencies of the moment[.]” *Id.* at 749–50 (quotations and citations omitted). To determine whether judicial estoppel should apply, the Federal Circuit considers three non-exclusive factors:

(1) whether the party’s position is clearly inconsistent with its earlier position; (2) whether the party has succeeded in persuading a [tribunal] to accept that party’s earlier position, so that judicial acceptance of an inconsistent position in a later proceeding would create the perception that either the first or the second [tribunal] was misled; (3) whether the party seeking to assert an inconsistent position would derive an unfair advantage or impose an unfair detriment on the opposing party if not estopped.

Trs. in Bankr. of N. Am. Rubber Thread Co. v. United States, 593 F.3d 1346, 1354 (Fed. Cir. 2010) (citing *New Hampshire*, 532 U.S. at 749).

Because all three judicial estoppel factors are present, Oak should be estopped from arguing for a different scope of the “oxide of titanium” genus than it obtained in the litigation against Samsung. *First*, any argument from Oak that the “oxide of titanium” genus does not include TiSiO_x would contradict Acorn’s earlier position that the “oxide of titanium” genus does include TiSiO_x . *Second*, Acorn prevailed in the infringement trial based on the interpretation that the “oxide of titanium” genus includes TiSiO_x . *Third*, Oak would derive an unfair advantage if it were permitted to advocate for inconsistent constructions of its patent claims. Thus, Oak should be precluded from asserting that the “oxide of titanium” genus does not include ternary compounds, such as, TiSiO_x . See *Trs. in Bankr.*, 593 F.3d at 1356; see also *Trs. of Columbia Univ. v. NortonLifeLock, Inc.*, No. 3:13cv808, 2019 WL 7040931, at *3–6 (E.D. Va. Dec. 20, 2019).

B. Ancestor applications of the ’395 Patent fail to adequately describe an interface layer that comprises an “oxide of titanium”

As discussed above, Claims 11-14 and 17-28 cannot obtain their alleged August 12, 2002 priority date unless all of the ’395 Patent’s ancestor applications provide written description support for every limitation of these claims. *In re NTP*, 654 F.3d at 1277. “[T]he test for sufficiency is whether the disclosure of the application relied upon reasonably conveys to those skilled in the art that the inventor

had possession of the claimed subject matter as of the filing date.” *Ariad Pharm., Inc. v. Eli Lilly & Co.*, 598 F.3d 1336, 1351 (Fed. Cir. 2010) (en banc); *see also Juno Therapeutics, Inc. v. Kite Pharma, Inc.*, 10 F.4th 1330, 1336 (Fed. Cir. 2021) (finding that the “written description fails to provide a representative sample of species within, or defining characteristics for, [an] expansive genus” when the patent-at-issue discloses only two species). Thus, “[a] disclosure in a parent application that merely renders the later-claimed invention obvious is not sufficient to meet the written description requirement; the disclosure must describe the claimed invention with all its limitations.” *Tronzo v. Biomet, Inc.*, 156 F.3d 1154, 1158 (Fed. Cir. 1998).

To support a claim to a genus, the specification must disclose “either a representative number of species falling within the scope of the genus or structural features common to the members of the genus so that one of skill in the art can ‘visualize or recognize’ the members of the genus.” *Ariad*, 598 F.3d at 1350 (citation omitted); *see also Juno*, 10 F.4th at 1336. Here, Claims 11-14 and 17-28 require an “oxide of titanium” in an interface layer. (Ex.1001, Claims 11-14 and 17-28.) The only possible example of an “oxide of titanium” for an interface layer described in any earlier parent application is a ***TiO₂ spacer layer***. (Ex.1001, 18:6-8; Ex.1022,

¶93.)¹⁰ Thus, the relevant question is whether the statement in earlier parent applications that “[s]pacer layers may be used with lower barriers (e.g., TiO₂ has a barrier of less than 1 eV)” provides written description of the entire “oxide of titanium” genus. (Ex.1001, 18:6-8.) And the answer is no, as further explained below:

First, although Claims 11-14 and 17-28 purport to cover any “oxide of titanium,” the Priority Applications provide a **single** example: titanium dioxide (TiO₂). “[A] patentee will not be deemed to have invented species sufficient to constitute the genus by virtue of having disclosed a single species.” *In re Curtis*, 354 F.3d 1347, 1358 (Fed. Cir. 2004); ; *see also Juno*, 10 F.4th at 1336.

¹⁰ The Board has found that although incorporated-by-reference U.S. Patent No. 6,833,556 describes a generic metal oxide and four example metal oxides, those metal oxides are only used to electrically isolate a transistor’s gate from its channel “such that essentially no current flows between the gate 270 and the channel 220”—not for an interface layer through which current does flow, as is claimed. Moreover, none of the examples disclosed (zinc oxide, aluminum oxide, zirconium oxide, and hafnium oxide) is an oxide of titanium. (Ex.1091, 18; Ex.1005, 7:60-8:22; *see also id.*, 13:44-14:20; Ex.1001, 14:58-65; Ex.1022, ¶96.)

Second, the single disclosed species—TiO₂—is not representative of the entire genus of “oxide of titanium,” and the specification does not describe features common to all members of the claimed genus. (Ex.1022, ¶97.) There are numerous materials that fall within the “oxide of titanium” genus, including several binary and ternary compounds as discussed above, and these materials exhibit a very broad range of properties. (Ex.1022, ¶¶99-103, 108-162.) Specifically, the “oxide of titanium” genus includes not only dielectric compounds (i.e., insulators), but also metallic compounds and semiconductive compounds because different species of “oxide of titanium” have vastly different electrical and structural properties. (Ex.1022, ¶¶108-162.) The genus of “oxide of titanium” encompasses all of them.

There are many different properties that affect the characteristics of the compounds within the “oxide of titanium” genus and the applications for which those compounds may be employed. (*Id.*) Some of the non-limiting exemplary properties of the species of the genus include: (a) electrical (tunneling and bulk) conductivity (*or* resistivity); (b) barrier height; (c) electron affinity; (d) bandgap energy; (e) dielectric constants; (f) structural characteristics; (g) melting point; and (h) optical transparency. (Ex.1022, ¶108.) As discussed below, none of these properties exhibit a characteristic that is common to all the species in the “oxide of titanium” genus.

1. Electrical conductivity (or resistivity)

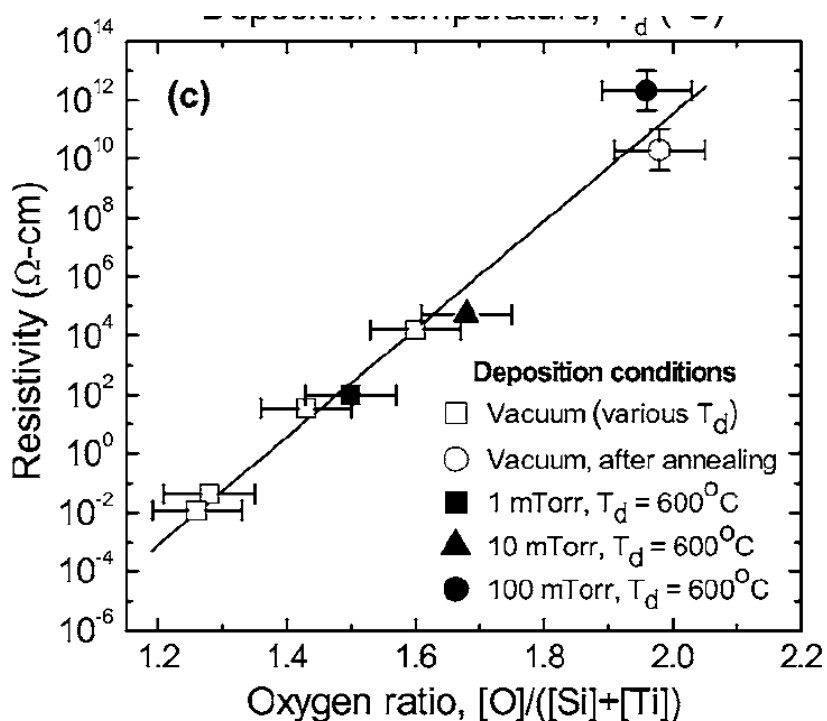
The electrical conductivity (or resistivity)¹¹ of an “oxide of titanium” as used in an interface layer in a metal-semiconductor junction directly affects the specific contact resistivity of the junction. (Ex.1022, ¶¶111-112.) The Board also recognized that “[t]he electrical conductivity of a metal oxide is an important property for the recited genus because electrical conductivity directly affects the specific contact resistance of a junction, which is an important property for the ’395 patent’s disclosure.” (Ex.1091, 20 n.3.)

That TiO₂ is insufficient to represent the full scope of the claimed genus is evident when only a *single* property—electrical conductivity—is compared between different species of oxides of titanium. TiO₂ (titanium dioxide) is an oxide of titanium with *semi-conductive* properties (which may vary depending on the impurity content). (Ex.1022, ¶115.) Mirroring the semi-conductive property, the electrical resistivity (ρ) of TiO₂ ranges from 1×10^4 to $1 \times 10^7 \Omega \text{ m}$. (Ex.1078, 88; Ex.1022, ¶115.)

Based upon their *composition*, the conductivity of compounds within the “oxide of titanium” genus varies considerably and ranges from *conductors* at one end to *insulators/dielectrics* at the other end. (Ex.1022, ¶115.) For example, the

¹¹ Electrical conductivity is the reciprocal of electrical resistivity. (Ex.1022, ¶112.)

conductivity of oxides of titanium composed of titanium, silicon, and oxygen (i.e., TiSi_xO_y) varies widely depending on the level of oxygen of the compound. (*Id.*, ¶116.) Fig. 6(c) of 2005-Brassard shows that titanium silicates (TiSi_xO_y) with high levels of oxygen content are insulators whereas titanium silicates with low levels of oxygen are conductors:



(Ex.1035, 054912-6, Fig. 6(c).) When oxygen and titanium are present in equal proportion (e.g., TiO), the compound acts like a **conductor** or has metallic properties. However, when oxygen content is high (e.g., 60% or more as in TiSiO_4) the compound acts like an **insulator**. (Ex.1022, ¶¶117-120.)

In addition to **composition**, the electrical conductivity of compounds in the “oxide of titanium” genus varies significantly based on **environmental conditions**,

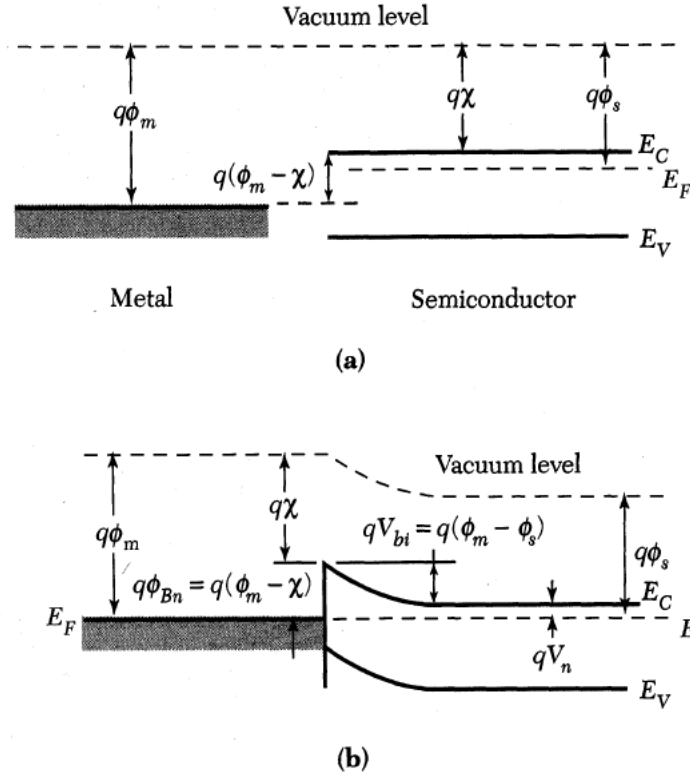
such as temperature (*Id.*, ¶121.) For example, Ti_3O_5 behaves like a semiconductor at room temperature, but becomes conductive at higher temperatures. (*Id.*) The conductivity of oxides of titanium also varies based on their ***growth or film deposition conditions***, such as oxygen pressure and deposition temperature. (*Id.*, ¶¶122-124.) For example, the conductivity is low when the films are deposited at low oxygen pressure, but when oxygen pressure is increased, the resistivity increases rapidly and highly insulating films are obtained. (*Id.*, ¶123.) The resistivity of titanium silicate films deposited under vacuum decreases when the deposition temperature is increased. (*Id.*, ¶124.)

In light of the broad range of variation in the conductivity within the “oxide of titanium” genus depending on the composition, environmental conditions, and growth (deposition) conditions, the disclosure of “ TiO_2 ” with “a barrier less than 1 eV” alone does not convey to a POSITA the entire “oxide of titanium” genus. (*Id.*, ¶125.)

2. Barrier height

In a metal-semiconductor junction, the barrier height represents the energy an electron needs to overcome to move from the semiconductor to the metal or vice versa. Thus, barrier height influences the electrical characteristics of the junction, and impacts the specific contact resistivity. (Ex.1107, 72-74; Ex.1022, ¶126.) Fig. 2(a) from the Sze Textbook (excerpted below) is the energy band diagram of an

isolated metal adjacent to an isolated n-type semiconductor and Fig. 2(b) is a diagram for a metal-semiconductor junction:



(Ex.1107, Figs. 2(a), 2(b), and 226.) The concept of barrier height is related to work function and electron affinity, and as shown in Fig. 2(b), barrier height ($q\phi_{Bn}$) of a metal-semiconductor junction is the difference between the metal's work function and the semiconductor's electron affinity:

$$q\phi_{Bn} = q\phi_m - q\chi$$

(Ex.1107, 226). The electron affinity $q\chi$ is the energy difference between the conduction band edge E_C and the vacuum level in the semiconductor (i.e., level at which an electron has no potential energy). (*Id.*) The work function $q\phi_s$ is the energy difference between the Fermi level E_F and the vacuum level in the semiconductor.

(*Id.*) The work function of a metal $q\phi_m$ is an inherent property of the metal and does not vary. Thus, the barrier height varies along with the electron affinity $q\chi$. (Ex.1022, ¶126.) The choice of metal and the semiconductor to form the junction influences barrier height, which in turn influences the specific contact resistance. (*Id.*)

Species within the “oxide of titanium” genus can have a broad range of barrier heights. Some species can exhibit a barrier height that is equal to or higher than 1 eV. (*Id.*, ¶¶128-129.) For example, the barrier heights of some species of titanium aluminates relative to silicon conduction band (or the aluminum Fermi level) are higher than or equal to 1 eV and not less than 1 eV in some instances. (*Id.*) Further, metallic compounds, such as TiO (and likely Ti_3O and Ti_2O), do not have a barrier height because they behave like metals. (*Id.*, ¶131.) Accordingly, the species of the oxide of titanium genus cannot be characterized as fitting the description of having “a barrier of less than 1 eV.” (*Id.*, ¶¶127, 132.) The limited disclosure in the specification of the ’395 Patent does not convey the entire genus to a POSITA. (*Id.*)

3. Electron affinity

As discussed above, in a metal-semiconductor junction, electron affinity $q\chi$ is the energy required to move an electron from the semiconductor’s conduction band to the vacuum level. (Ex.1022, ¶133.) Electron affinity, along with the work function of a metal $q\phi_m$, determines the barrier height of the junction and the resistance of the junction. (*Id.*; see also *id.*, ¶¶134-135.)

The electron affinity of TiO_2 (a semiconductor) is 4.0 eV. (Ex.1087, 3; Ex.1022, ¶137.) Different compounds in the “oxide of titanium” genus have different electron affinities. (*Id.*, ¶136.) If, in terms of electrical conductivity, a compound in the “oxide of titanium” genus behaves like a metal (e.g., TiO), then its properties are more appropriately described by a metal work function. (*Id.*, ¶137) Further, electron affinities of some of the oxides of titanium (e.g., Ti_2O_3 and TiSiO_4) are not even known. (*Id.*) Thus, the electron affinity of TiO_2 does not convey the entire genus to a POSITA. (Ex.1022, ¶138.)

4. Bandgap energy

The bandgap energy E_g is the gap between the bottom of the conduction band and top of the valence band ($E_c - E_v$), as shown below in Fig. 15. (Ex.1107, 29; Ex.1022, ¶139.)

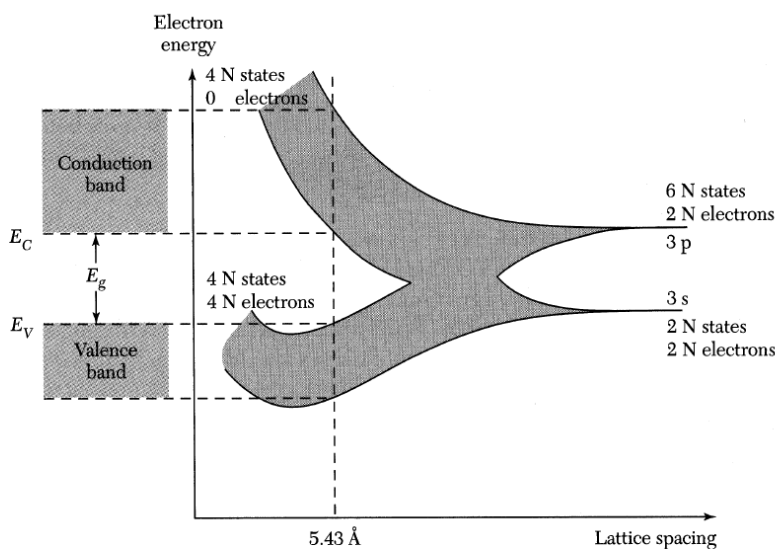


Fig. 15 Formation of energy bands as a diamond lattice crystal is formed by bringing isolated silicon atoms together.

(Ex.1107, 30.) E_g is the energy required to break a bond in the semiconductor to free an electron to the conduction band and leave a hole in the valence band. (*Id.*; Ex.1022, ¶139.) Higher bandgap energy E_g implies higher resistivity and smaller bandgap implies lower resistivity. Thus, the bandgap energy is a key factor in determining a material's electrical conductivity—a material's conductivity is inversely related to its bandgap energy. (*Id.*; *see also id.*, ¶¶140-142.)

The bandgap energy of TiO_2 is about 3.0 to 3.4 eV. (Ex.1074; Ex.1058; Ex.1022, ¶142.) Compounds in the “oxide of titanium” genus have different bandgap energies. (*Id.*) For example, TiO does not have a bandgap energy because it behaves like a metal, and the bandgap energies of Ti_2O_3 and TiSiO_4 are 0.1 eV and 1.75-2.68 eV, respectively. (*Id.*) Thus, the bandgap energy of TiO_2 does not convey the entire genus to a POSITA. (*Id.*, ¶143.)

5. Dielectric constant

The dielectric constant of a material is the ratio of the electrical permittivity of the material to the permittivity of vacuum. Permittivity of a material is its ability to store electrical energy in an electrical field. The dielectric constants are used to describe characteristics of insulators and thus determine the applications for which the insulators can be employed. (*Id.*, ¶145; *see also id.*, ¶146.)

TiO_2 is known to have a high dielectric constant with k values in excess of 80. (*Id.*, ¶147.) The dielectric constant also varies widely between different species in

the “oxide of titanium” genus when compared to the dielectric constant of TiO_2 . (*Id.*) For example, the dielectric constant of TiSiO_4 , $\text{Ti}_{0.5}\text{Si}_{0.5}\text{O}_2$, and $\text{Ti}_{0.51}\text{Si}_{0.49}\text{O}_2$ is around “16.5,” “higher than 20,” and “as high as 26,” respectively. (*Id.*) Thus, the dielectric constant of TiO_2 fails to convey the entire genus to a POSITA. (*Id.*, ¶148.)

6. Structural properties

Structural properties of a compound are associated with the spatial arrangement of its atoms, which in turn can affect the movement of charge carriers within the material. (Ex.1022, ¶¶149-151.)

TiO_2 crystallizes in three different structures: the rutile structure, anatase structure, and brookite structure. (*Id.*, ¶151.) Atoms in a crystal structure have specific positional relationships with each other. In each of the three crystal structures (rutile, anatase, and brookite), the constituent atoms have distinct positional relationships with each other. (*Id.*) The compounds in the “oxide of titanium” genus have different structural properties. (*Id.*, ¶¶152-153.) For example, many binary compounds, such as TiO , Ti_2O_3 , Ti_4O_7 , and Ti_3O_5 , are known to have different crystal structures. (*Id.*, ¶152.) Some ternary titanate compounds were also known to have a glass-like structure (e.g., TiSiO_4 , TiSi_xO_y). (*Id.*, ¶153.) Thus, no one structural property is common to all compounds that fall within the genus. (*Id.*, ¶154.)

7. Melting point

The melting point of an “oxide of titanium” is important when considering its usefulness in semiconductor manufacturing because it is indicative of high-temperature structural stability and affects the reliability and manufacturability of the device employing the compound. (Ex.1022, ¶¶155-156.)

The melting point of TiO_2 is $1,855^\circ \text{C}$. (*Id.*, ¶155) The melting point of different species of the genus can vary, from $1,700^\circ \text{C}$ to $2,130^\circ \text{C}$. (*Id.*, ¶155.) Thus, the melting point of TiO_2 does not convey the entire genus to a POSITA. (*Id.*, ¶157.)

8. Optical transparency

The optical transparency gives an indication of the bandgap energy, with opaque materials having a lower bandgap energy, and transparent materials having a higher bandgap energy. (*Id.*, ¶158.) The optical transparency may have a significant influence in semiconductor manufacturing. (*Id.*, ¶159.)

TiO_2 is optically transparent in the visible wavelength range (corresponding to high optical transparency). (*Id.*, ¶160.) The species of the genus can have different optical reflectivity, absorbency, opacity, and transparency—from transparent or partially transparent to opaque or black. (*Id.*) Thus, the optical transparency of TiO_2 does not describe the entire genus to a POSITA. (*Id.*, ¶161.)

* * *

The table below compares just a handful of binary and ternary compounds of oxides of titanium that could be used in semiconductor devices with the seven exemplary properties to illustrate their disparate nature, including properties that are diametrically opposite, exhibited by different oxides of titanium:¹²

Properties	TiO	TiO ₂	Ti ₂ O ₃	Ti ₃ O ₅	TiSiO ₄
Electrical conductivity	Conductor	SemiC	SemiC at RoomT exhibiting SemiC-to-M at higher temp.	SemiC at RoomT exhibiting SemiC-to-M at higher temp.	Insulator
Electron affinity	None	4 eV	Probably unknown	Probably unknown, but relatively small	Probably unknown
Bandgap energy	None (metallic)	3.0-3.4 eV	0.1 eV	Small bandgap with semiconductor-to-metal transition at 440 K	1.75-2.68 eV
Dielectric constant		80			16.5

¹² SemiC refers to semiconductor; RoomT refers to room temperature; SC-to-M refers to transition from semiconductor properties to metal properties. The blank entries in the table indicate that data is not available.

Properties	TiO	TiO ₂	Ti ₂ O ₃	Ti ₃ O ₅	TiSiO ₄
Structural properties	Monoclinic and cubic	Rutile, anatase and brookite	Corundum	Anosovite and monoclinic	Glass-like (no structure)
Melting point	1,700 °C	1,855 °C	2,130 °C	1,700 °C	
Optical transparency	Reflective (similar to a metal)	Transparent (high)	Optically absorbing and opaque (“dark violet”)	Optically absorbing and opaque (black colored)	Partially transparent

(Ex.1022, ¶162.)

The table above does not even consider all the equilibrium and non-equilibrium species¹³ of the binary and the ternary species of genus that collectively exhibit even broader disparities in the characteristics. (Ex.1022, ¶¶99-103.) For example, titanium silicate (TiSi_xO_y) is a ternary compound of oxide of titanium, and its electrical conductivity changes considerably—from a metal to an insulator—

¹³ In the semiconductor fabrication process, nonequilibrium compounds can form because the products are fabricated in nonequilibrium conditions. (Ex.1022, ¶101; Ex.1048, 50:25-51:13.) Acorn argued in the Acorn Litigation that the oxide of titanium includes nonequilibrium compounds. (Ex.1043, 5 (identifying “TiSiO_x” in the interface layer).)

depending upon growth conditions (e.g., film deposition conditions), including oxygen pressure and deposition temperature. (*Id.*, ¶¶115-119.) Further, properties of some of the species of “oxide of titanium”—such as TiO₂ and non-stoichiometric compounds—were not entirely well understood. (*Id.*, ¶¶163-167.) Thus, a POSITA would not have known whether certain species in the “oxide of titanium” genus would be suitable as an interface layer. (*Id.*)

The variations show that neither TiO₂ nor “lower barriers” represents the full genus of oxides of titanium. Those disclosures, whether taken alone or together, do not reflect the full variation across the genus of oxide of titanium. Thus, no application prior to U.S. Patent App. No. 15/048,877 provides written description of a generic “oxide of titanium” interface layer.

Indeed, “[a] patentee will not be deemed to have invented species sufficient to constitute the genus by virtue of having disclosed a single species when, as is the case here, the evidence indicates ordinary artisans could not predict the operability in the invention of any species other than the one disclosed.” *In re Curtis*, 354 F.3d 1347, 1358 (Fed. Cir. 2004). *In re Curtis* involved claims directed to PTFE dental floss reciting a genus of friction-enhancing coatings, but the specification identified only one friction-enhancing coating: microcrystalline wax (MCW). *See id.* at 1349, 1358. Because neither the specification nor any other evidence conveyed that any other coating was suitable as a friction-enhancing coating for PTFE dental floss, the

Federal Circuit held that the lone disclosed example could not support a claim to a genus of friction-enhancing coatings. *See id.* at 1358; *see also Juno*, 10 F.4th at 1336.

Like the lone example in *In re Curtis*, TiO₂ is the only “oxide of titanium” layer disclosed in the parent applications predating U.S. Patent App. No. 15/048,877. Acorn alleged that the operability of the claimed interface layers was unpredictable; indeed, it alleged that using *any* interface layer was “counter-intuitive.” (Ex.1038 ¶¶6, 48; Ex.1022, ¶97.) Oak also alleges that the inventors found this result “remarkable.” (Ex.1095, ¶¶37-39.) Thus, just as the lone example of MCW in *In re Curtis* could not support a claim to the genus of friction-enhancing coatings, the previous parent applications’ lone example of TiO₂ as a spacer layer cannot support claims to a generic “oxide of titanium” for an interface layer. Accordingly, no Challenged Claim requiring an “oxide of titanium” can possibly obtain a priority date earlier than February 19, 2016, the filing date of U.S. Patent App. No. 15/048,877. (Ex.1022, ¶¶86, 88-98.)

In light of the arguments made by Acorn during the earlier filed petitions, Oak may argue that the disclosure of TiO₂ is sufficient to support the “oxide of titanium” genus because it discloses structural features common to the members of the genus so that a skilled artisan can envision the entire genus. (Ex.1091, 17.) Oak may argue that because the oxide of titanium is in the spacer layer, a common structural feature of oxides of titanium used for such purpose is that they are dielectrics. *Id.* The Board

should reject Oak’s arguments for the same reason it rejected Acorn’s arguments. The Board noted that “[t]he ’423 patent [parent of ’395 Patent with same specification] does not discuss any properties of metal oxides (other than the lower barrier of the metal oxide TiO₂) or design considerations concerning the selection of particular oxides to use in the claimed structure, particularly in the context of MIGS separation.” *Id.*, 24. Thus, the Board did not credit Acorn’s analysis that a skilled artisan would have found that the inventors possessed the recited genus. *Id.*, 25 (citing *Martin v. Meyer*, 823 F.2d 500, 505 (Fed. Cir. 1987) (holding that the written description is “not a question whether one skilled in the art *might* be able to construct the patentee’s device from the teachings of the disclosure Rather, it is a question whether the application necessarily discloses that particular device.”) (emphasis original)).

XII. THE CHALLENGED CLAIMS ARE UNPATENTABLE

A. Ground 1: Grupp ’483 anticipates Claims 17-28

1. Claim 17

a) An electrical junction, comprising:

To the extent the preamble is limiting, Grupp ’483 discloses it. For example, “[i]n one embodiment, the present invention provides an electrical junction that includes a semiconductor (e.g., C, Ge, or an Si-based semiconductor), a conductor, and an interface layer disposed therebetween.” (Ex.1021, 3:44-47; *see also id.*, 3:18-22, 5:49-58, 19:26-27.)

b) a source or drain of a transistor, said source or drain comprising a semiconductor,

Grupp '483 discloses this limitation. For example, “[t]he present inventors have determined that for thin interface layers disposed between a metal and a semiconductor (e.g., C, Ge, Si, SiC and SiGe), so as to form a metal—interface layer—semiconductor junction, there exist corresponding minimum specific contact resistances.” (Ex.1021, 3:18-22.) “In one embodiment, the present invention provides an electrical junction that includes a semiconductor (e.g., C, Ge, or an Si-based semiconductor), a conductor, and an interface layer disposed therebetween.” (*Id.*, 3:44-47.)

Grupp '483 describes that its invention is generally applicable to a broad category of metal-semiconductor contacts, which can include contacts to the source or drain of a transistor: “[t]he source and drain contacts at the channel of a field effect transistor are examples of a broader category of metal-interface layer-semiconductor contacts that make up the present invention.” (*Id.*, 18:32-35.)

One example of a region in a semiconductor substrate that Grupp '483 discloses is a source or drain of a transistor. In a section on “Transistors Containing Passivated Semiconductor Surfaces,” Grupp '483 discloses that “the junction of the present invention can be used in making contacts to source or drain implanted wells and will have the advantage of reducing the need for high doping levels (which are now reaching their limits of solid solubility).” (Ex.1021, 18:19-20, 19:11-15.) In a

transistor, a ‘well’ is a doped region of a semiconductor in which source and drain regions are formed by implanting dopants; the source and drain regions have a doping opposite that of the well. (Ex.1022, ¶181.)

- c) **a metal electrical contact to said source or drain, and an interface layer disposed between and in contact with said source or drain and said metal electrical contact,**

Grupp ’483 discloses this limitation. Grupp ’483 describes that its invention is generally applicable to a broad category of metal-semiconductor contacts, which can include contacts to the source or drain of a transistor that is formed in a semiconductor region. (Ex.1021, 18:32-35.) Further, Grupp ’483 discloses an interface layer disposed between and in contact with the source or drain of a transistor and a metal (i.e., metal electrical contact). For example, “[i]n further embodiments the present invention provides an electrical device in which *an interface layer is disposed between and in contact with a metal and a semiconductor . . .*” (Ex.1021, 4:21-23; *see also id.*, Fig. 7d, 3:18-22, 3:44-47, 5:49-58, 18:4-17.) Grupp ’483 also discloses that the junction of the present invention can be used in making contacts to source or drain implanted wells. (Ex.1021, 18:19-20, 19:11-15.)

d) said source or drain being electrically connected to said metal electrical contact through said interface layer and

Grupp '483 discloses this limitation. For example, “the present invention provides an electrical device in which an interface layer is disposed between and in contact with a metal and a semiconductor and is configured to depin the Fermi level of the semiconductor while still *permitting current flow between the metal and the semiconductor* when the electrical device is biased.” (Ex.1021, 4:21-26.) Grupp '483 describes that its invention includes contacts to the source or drain of a transistor: “[t]he source and drain contacts at the channel of a field effect transistor are examples of a broader category of metal-interface layer-semiconductor contacts that make up the present invention.” (*Id.*, 18:32-35.)

e) said interface layer comprising an oxide of titanium and an oxide of the semiconductor.

Grupp '483 discloses this limitation. Grupp '483 discloses an interface layer that includes (1) a passivation layer, which can be a semiconductor oxide; and (2) a separation layer, which can be titanium dioxide, a metal oxide.

First, for the oxide of semiconductor for passivation, Grupp '483 discloses, for example, “[t]he interface layer includes a passivating material, for example, a nitride, a fluoride, an *oxide*, an oxynitride, a hydride and/or an arsenide *of the semiconductor*, and in some cases may also include a separation layer.” (Ex.1021,

3:53-56; *see also id.*, 4:28-31, 4:53-55, 8:64-9:10, 9:39-43, 10:34-44, 10:48-54, 10:60-63, 11:35-38, 13:41-46.)

Second, for the oxide of titanium separation layer, Grupp '483 discloses that the separation layer can be an oxide. (Ex.1021, 11:35-38.) More specifically, the separation layer can be a “spacer layer” of TiO₂, which is titanium dioxide: “[s]pacer layers may be used with lower barriers (e.g., TiO₂ has a barrier of less than 1 eV).” (*Id.*, 18:65-67; *see also id.*, 18:45-65.)

Thus, Grupp '483 discloses an interface layer comprising a metal oxide (titanium dioxide) and an oxide of the semiconductor.

2. Claim 18

a) The electrical junction of claim 17,

Grupp '483 discloses the electrical junction of Claim 17, as discussed above in **Section XII.A.1.a).**

b) wherein said metal electrical contact includes titanium.

Grupp '483 discloses this limitation. As discussed above in **Section XII.A.1.c)),** Grupp '483 discloses a metal electrical contact. Further, Grupp '483 discloses using titanium (Ti) as the metal electrical contact. (Ex.1021, 4:13-20, 14:58-15:2, Claim 7.)

3. Claim 19

a) The electrical junction of claim 18,

Grupp '483 discloses the electrical junction of Claim 18, as discussed above in **Section XII.A.2.**

b) wherein said semiconductor comprises silicon.

Grupp '483 discloses this limitation. As discussed above in **Section XII.A.1.b)**, Grupp '483 discloses silicon as an example of the semiconductor. (Ex.1021, 3:19-20, 3:44-47.) Grupp '483 also discloses wherein said semiconductor oxide comprises an oxide of silicon.

4. Claim 20

a) The electrical junction of claim 17,

Grupp '483 discloses the electrical junction of Claim 17, as discussed above in **Section XII.A.1.**

b) wherein said metal electrical contact includes tungsten.

Grupp '483 discloses this limitation. As discussed above in **Section XII.A.1.c)**, Grupp '483 discloses a metal electrical contact. Further, Grupp '483 discloses using tungsten (W) as the metal electrical contact. (Ex.1021, 4:13-20, 14:58-15:5, Claim 8.)

5. Claim 21

a) The electrical junction of claim 20,

Grupp '483 discloses the electrical junction of Claim 20, as discussed above in **Section XII.A.4.**

b) wherein said semiconductor comprises silicon.

Grupp '483 discloses this limitation, as discussed in **Section XII.A.3.b).**

6. Claim 22

a) The electrical junction of claim 17,

Grupp '483 discloses the electrical junction of Claim 17, as discussed above in **Section XII.A.1.**

b) wherein said semiconductor comprises silicon.

Grupp '483 discloses this limitation, as discussed in **Section XII.A.3.b).**

7. Claim 23

a) A semiconductor device, comprising:

To the extent the preamble is limiting, Grupp '483 discloses a semiconductor device. (*See, e.g.*, Ex.1021, 1:23-24, 5:24-28, 9:56-59.)

b) a semiconductor region,

Grupp '483 discloses this element. For example, Grupp '483 discloses a semiconductor junction, i.e., an electrical junction including a semiconductor. Specifically, Grupp '483 discloses that the source and drain in the electrical junction

comprises a semiconductor, as discussed in **Section XII.A.1.b)**. In other words, the source and drain is a semiconductor region.

c) a metal electrical contact to said semiconductor region, and

Grupp '483 discloses this element. Grupp '483 discloses a metal electrical contact to a source or drain, i.e., a semiconductor region, as discussed in **Section XII.A.1.c)**.

d) an interface layer disposed between and in contact with said semiconductor region and said metal electrical contact,

Grupp '483 discloses this limitation. As discussed above in **Section XII.A.1.c)**, Grupp '483 discloses an interface layer disposed between and in contact with said semiconductor region (i.e., a source or drain) and said metal electrical contact.

e) said semiconductor region being electrically connected to said metal electrical contact through said interface layer and

Grupp '483 discloses this limitation. As discussed above in **Section XII.A.1.d)**, Grupp '483 discloses that the semiconductor region (i.e., a source or drain) is electrically connected to said metal electrical contact through said interface layer.

- f) said interface layer comprising an oxide of titanium and an oxide of the semiconductor region.**

Grupp '483 discloses this limitation. As discussed above in **Section XII.A.1.e)**, Grupp '483 discloses that the interface comprises an oxide of titanium and an oxide of the semiconductor. Further, Grupp '483 discloses that the oxide of the semiconductor is in an oxide of the semiconductor region because Grupp '483 discloses that an oxide of the semiconductor can form a distinct separate layer as a passivation layer, i.e., an oxide of the semiconductor region. *See Section XII.A.1.e).*

8. Claim 24

- a) The semiconductor device of claim 23,**

Grupp '483 discloses a semiconductor device of claim 23, as discussed above in **Section XII.A.7.**

- b) wherein said metal electrical contact includes titanium.**

Grupp '483 discloses this limitation, as discussed in **Section VII.A.2.b).**

9. Claim 25

- a) The semiconductor device of claim 24,**

Grupp '483 discloses a semiconductor device of claim 24, as discussed above in **Section XII.A.8.**

- b) wherein said semiconductor region comprises silicon.**

Grupp '483 discloses this limitation. As discussed above in **Section XII.A.7.b)**, a source or drain Grupp '483 discloses that the source and drain is a

semiconductor region. Further, as discussed above in **Section XII.A.3.b)**, Grupp '483 discloses silicon as an example of semiconductor. Grupp '483 discloses that the source and drain (i.e., a semiconductor region) comprises silicon.

10. Claim 26

a) The semiconductor device of claim 23,

Grupp '483 discloses a semiconductor device of claim 23, as discussed above in **Section XII.A.7.**

b) wherein said metal electrical contact includes tungsten.

Grupp '483 discloses this limitation, as discussed in **Section XII.A.4.b).**

11. Claim 27

a) The semiconductor device of claim 26,

Grupp '483 discloses a semiconductor device of claim 26, as discussed above in **Section XII.A.10.**

b) wherein said semiconductor region comprises silicon.

Grupp '483 discloses this limitation, as discussed in **Section XII.A.9.b).**

12. Claim 28

a) The semiconductor device of claim 23,

Grupp '483 discloses a semiconductor device of claim 23, as discussed above in **Section XII.A.7.**

b) wherein said semiconductor region comprises silicon.

Grupp '483 discloses this limitation, as discussed in **Section XII.A.9.b).**

B. Ground 1: Grupp '483 anticipates claims 7 and 11-14

1. Claim 7

Grupp '483 anticipates Claim 7.

a) The electrical junction of claim 1,

To the extent the preamble is limiting, Grupp '483 discloses an electrical junction. The Board has concluded that claim 1 is not entitled to the benefit of any pre-2011 priority applications and that Grupp '483 anticipates claim 1. (Ex.1091, 26.) For example, “in one embodiment, the present invention provides an electrical junction that includes a semiconductor (e.g., C, Ge, or an Si-based semiconductor), a conductor, and an interface layer disposed therebetween.” (Ex.1021, 3:44-47; *see also id.*, 3:18-22, 5:49-58, 19:26-27.)

b) wherein said metal electrical contact comprises an alloy of metal.

Grupp '483 discloses a metal electrical contact that comprises an alloy of metal. Fig. 6 of Grupp '483 discloses “a diode 600 containing . . . an interface layer 620 disposed between and attached to both a semiconductor 610 and a conductor 630.” (Ex.1021, 13:63-66.) “The conductor 630 contains a conductor material such as a metal or an alloy of a metal.” (*Id.*, 14:5-6; *see also id.*, 14:11-35.)

2. Claim 11

a) The electrical junction of claim 1,

To the extent the preamble is limiting, Grupp '483 discloses it, as discussed in **Section XII.B.1.a).**

b) wherein said metal oxide comprises an oxide of titanium.

Grupp '483 discloses this limitation. Grupp '483 discloses an interface layer that includes a separation layer, which can be a “spacer layer” of TiO₂, which is titanium dioxide: “[s]pacer layers may be used with lower barriers (e.g., TiO₂ has a barrier of less than 1 eV).” (Ex.1021, 18:65-67; *see also id.*, 18:45-65.) Thus, Grupp '483 discloses that the metal oxide comprises an oxide of titanium.

3. Claim 12

a) The electrical junction of claim 11,

Grupp '483 discloses the electrical junction of Claim 11, as discussed above in **Section XII.B.2.**

b) wherein said semiconductor oxide comprises an oxide of silicon.

Grupp '483 discloses this limitation. Grupp '483 discloses using a semiconductor oxide as a passivating material. (Ex.1021, 3:53-56.) Further, Grupp '483 discloses using either an oxide of silicon (Ex.1021, 10:27-34, 10:48-54, 10:60-63) or silicon dioxide (*id.*, 8:64-9:10) as the passivating semiconductor oxide. Thus, Grupp '483 discloses that the semiconductor oxide comprises an oxide of silicon.

4. Claim 13

a) The electrical junction of claim 12,

Grupp '483 discloses the electrical junction of Claim 12, as discussed above in **Section XII.B.3.**

b) wherein said semiconductor oxide comprises silicon dioxide.

Grupp '483 discloses wherein said semiconductor oxide comprises silicon dioxide. Specifically, Grupp '483 discloses using silicon dioxide, a well-known oxide of silicon, as a passivating material. (Ex.1021, 8:64-9:10.)

5. Claim 14

a) The electrical junction of claim 12,

Grupp '483 discloses the electrical junction of Claim 11, as discussed above in **Section XII.B.3.**

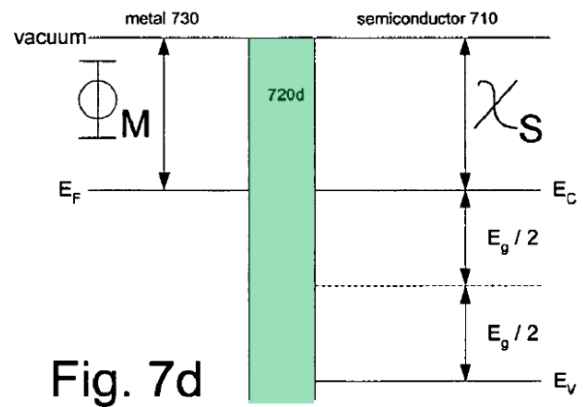
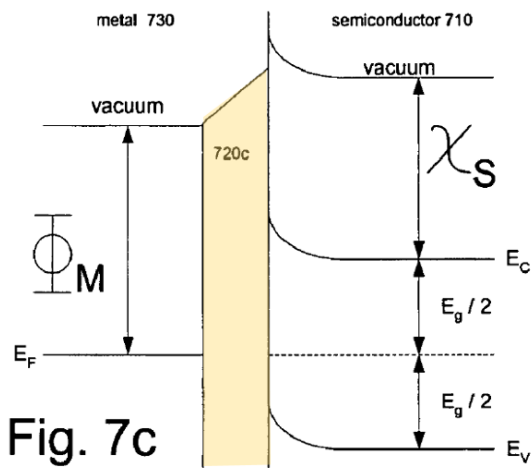
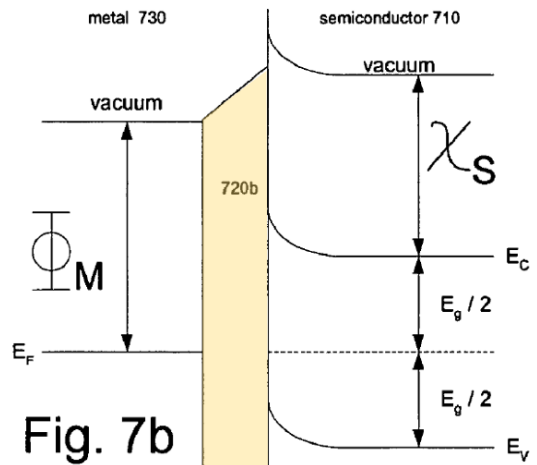
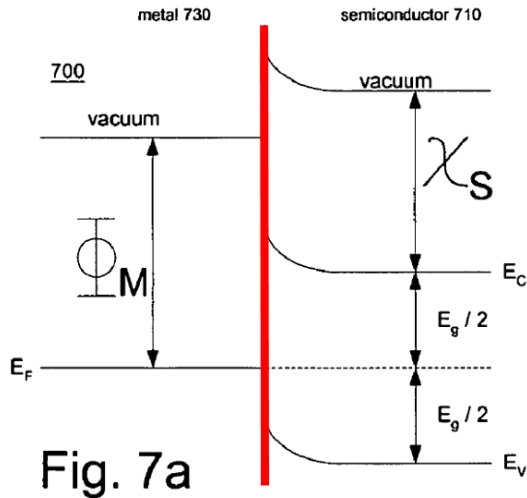
b) wherein said region in the semiconductor substrate comprises an n-type doped source or drain of a transistor.

Grupp '483 discloses this limitation.

Grupp '483 discloses the recited region in a semiconductor substrate. Grupp '483 discloses semiconductor substrates generally by describing its innovation as finding a minimum specific contact resistance using a thin interface layer “disposed between a metal and a semiconductor (e.g., C, Ge, Si, SiC and SiGe), so as to form a metal—interface layer—semiconductor junction[.]” (Ex.1021, 3:18-22; *see also*

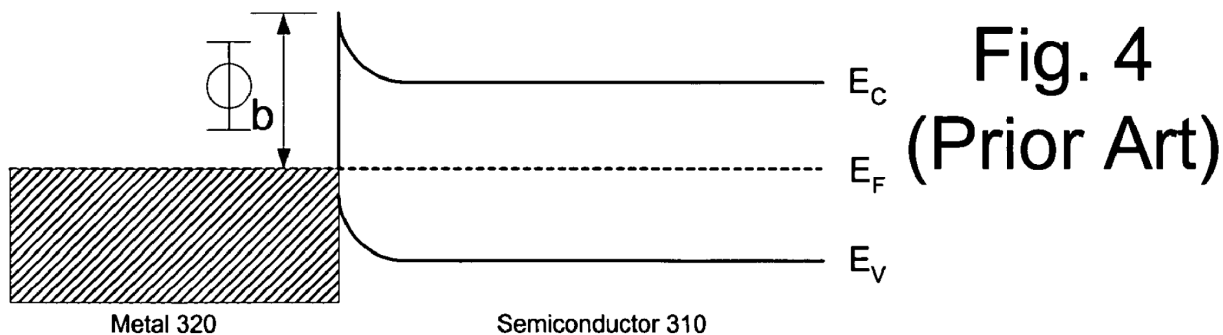
id., 3:44-47.) Grupp '483 discloses that the semiconductor can be an n-type doped semiconductor. (Ex.1021, 6:5-9.)

Further, Fig. 7d of Grupp '483 shows a metal-interface layer-semiconductor junction, in which the semiconductor is an n-type semiconductor. (Ex.1021, Fig. 4, Fig. 7a, Fig. 7d, 5:22-23, 5:37-40, 18:4-10.) In particular, Grupp '483 depicts a series of band diagrams for metal-semiconductor junctions in Figs. 7a-7d, where the metal can be aluminum, and where the semiconductor can be n-type silicon. (Ex.1021, 5:33-40, 17:50-18:17.) In contrast to Figs. 7b-7d, which depict interface layers 720b, 720c, and 720d between the metal 730 and the semiconductor 710, Fig. 7a does not depict any interface layer, indicating that the metal 730 and the semiconductor 710 are in **direct contact with no interface layer** in Fig. 7a.



(Ex.1021, Figs. 7a-7d (annotations added), 5:33-40, 17:50-18:17.)

As Dr. Schubert explains, Grupp '483's Fig. 7a depicts the same band bending as Grupp '483's Fig. 4, which is described as a junction between a metal and an n-type semiconductor:



(Ex.1021, Fig. 4, 5:22-23, 8:10-15; Ex.1022, ¶¶183-184.)

Grupp '483 explains that Fig. 4 depicts a junction between an n-type semiconductor and a metal with barrier height ϕ_b , which is the difference between the Fermi level of the metal E_F and the conduction band edge of the semiconductor E_c at the interface. (Ex.1021, 5:22-23, 8:10-15.) In light of Fig. 4 and its accompanying description, an ordinarily skilled artisan would have recognized that Figs. 7a-7d also depict a junction of an n-type semiconductor and a metal. (Ex.1021, Fig. 4, Fig. 7a, 5:22-23, 8:10-15, 18:4-17.) In particular, Fig. 7a, Fig. 7b, and Fig. 7c all depict band bending identical to that shown in Fig. 4, which depicts a metal to n-type semiconductor junction.

Grupp '483 additionally discloses “wherein said region in the semiconductor substrate comprises a source or drain of a transistor.” Grupp '483 describes that its invention is generally applicable to a broad category of metal-semiconductor contacts, which can include contacts to the source or drain of a transistor. (Ex.1021, 18:32-35.)

Further, in a section entitled “Transistors Containing Passivated Semiconductor Surfaces,” Grupp ’483 discloses that “the junction of the present invention can be used in making contacts to source or drain implanted wells and will have the advantage of reducing the need for high doping levels (which are now reaching their limits of solid solubility).” (Ex.1021, 18:19-20, 19:11-15; *see also id.*, 18:32-35.) In a transistor, a ‘well’ is a doped region of a semiconductor in which source and drain regions are formed by implanting dopants; the source and drain regions have a doping opposite that of the well. (Ex.1022, ¶182.)

In sum, Grupp ’483 discloses that the region in the semiconductor substrate can be both (1) n-type doped and (2) the source or drain of a transistor. Accordingly, Grupp ’483 discloses the limitation “wherein the semiconductor comprises an n-type doped source or drain of a transistor.”

As Dr. Schubert notes in his declaration, he has reviewed Ground 1 and has concluded that Grupp ’483 anticipates Claims 7, 11-14 and 17-28 of the ’395 Patent. (Ex.1022, ¶¶86, 181-182.)

C. Ground 2: Jammy renders claims 29 and 30 obvious

1. Claim 29

a) An electrical junction, comprising:

To the extent the preamble is limiting, Jammy discloses the preamble. As shown in Fig. 1 (reproduced below), Jammy discloses an “electrical contact.” (Ex.1101, 3:61-4:1.)

In the annotated Figure 1 below, “conductive studs 52 and 54 are in electrical *contact* with shallow source/drain diffusions (doped regions) 42 and 44 through quantum conductive barrier layers 56 and 58 respectively.” (Ex.1101, 4:9-17.) The conductive studs 52 and 54 and shallow source/drain diffusions (doped regions) 42 and 44 along with quantum conductive barrier layers 56 and 58 form an electrical junction. (Ex.1097, 27-28.)

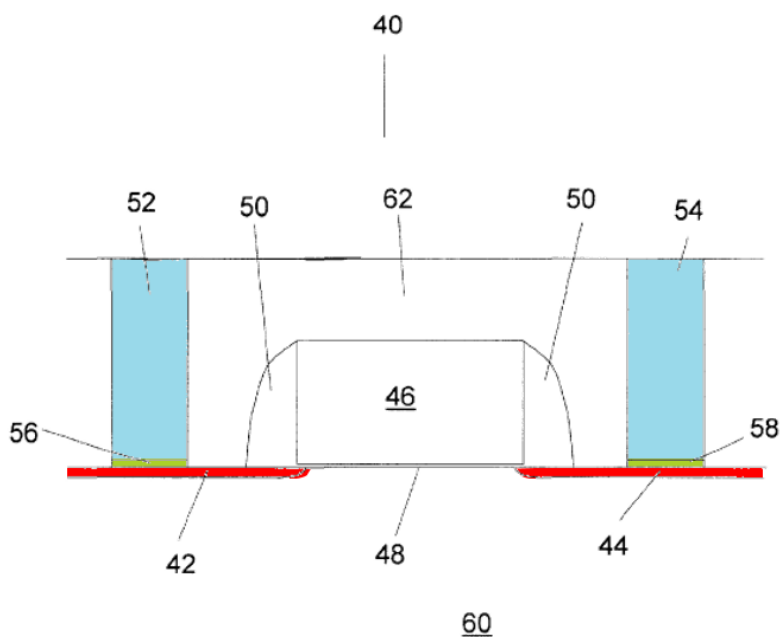


Figure 1

(Ex.1101, Fig. 1 (annotations added).) As the Board has previously found, the specification of the '395 Patent uses the terms “contact” and “junction” interchangeably. (Ex.1097, 18.) Thus, Jammy discloses an electrical junction.

b) a source or drain of a transistor, said source or drain comprising a semiconductor,

Jammy discloses this element. Jammy discloses a source or drain of a transistor, i.e., MOSFET. (Ex.1097, 27-28.) Jammy discloses that “FIG. 1 shows a schematic side view of a MOSFET [metal oxide semiconductor field effect transistor] 40 in a substrate 60. Shallow **source/drain diffusions (doped regions) 42 and 44** are formed in substrate 60.” (Ex.1101, 4:9-17.)

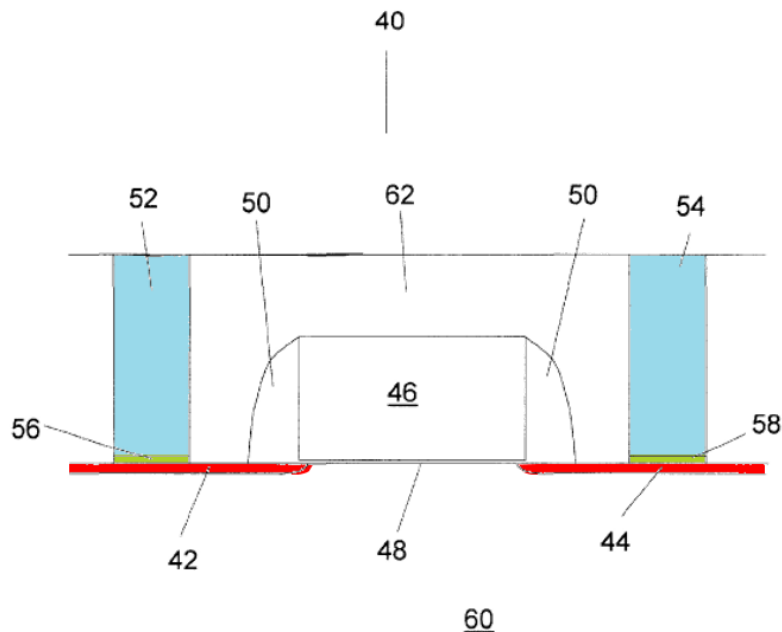


Figure 1

(Ex.1101, Fig. 1 (annotations added).)

Further, Jammy discloses that the source or drain comprises a semiconductor. Jammy discloses forming those **source/drain diffusions** by implanting n-type dopants into a silicon substrate, i.e., a semiconductor. (Ex.1101, 4:33-38 (“The

shallow diffusions would typically be formed by diffusing an appropriate N-type or P-type dopant into the substrate.”.)

c) a metal electrical contact to said source or drain, and

Jammy discloses this element. Jammy discloses that “[i]n the context of devices such as MOSFET transistors in semiconductor substrates, various materials are used to form the components of the transistor such as the source and drain diffusion regions, electrical contacts (studs) to the [source and drain] diffusion regions, . . .” (Ex.1101, 1:29-33) Fig. 1 specifically shows studs 52 and 54 to the source/drain diffusions 42 and 44.

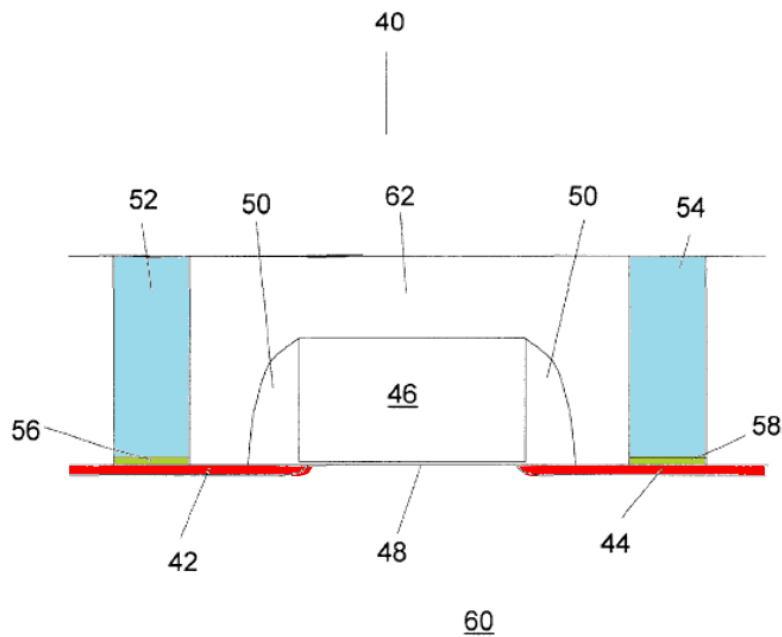


Figure 1

(Ex.1101, Fig. 1. (annotated)) Further, Jammy discloses that “the studs are typically metal.” (Ex.1101, 1:34; *see also id.*, 4:32-33; Ex.1097, 28.) Thus, the “studs” in Jammy are metal electrical contacts to the source or drain.

d) an interface layer disposed between and in contact with said source or drain and said metal electrical contact,

Jammy discloses this element. Jammy describes forming “a quantum conductive barrier layer at the interface between the conductive stud and shallow diffusion region.” (Ex.1101, 2:40-41.) In Jammy, “shallow diffusion regions” are formed in a substrate, as represented by elements 42 and 44 in Fig. 1. (*Id.*, 4:9-12.)

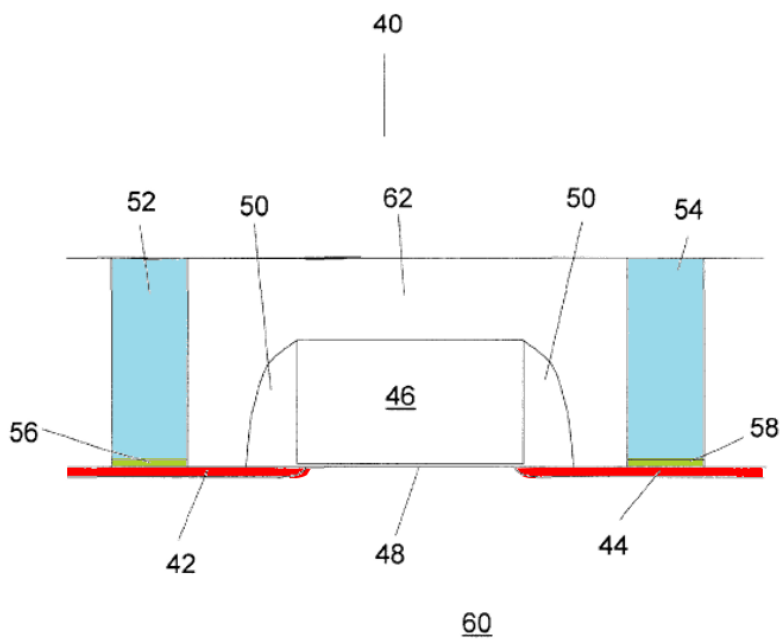


Figure 1

(Ex.1101, Fig. 1. (annotated).) Fig. 1 of Jammy shows that the quantum conductive barrier layers 56 and 58 are between and in contact with the source/drain diffusions

42 and 44 and the studs 52 and 54. (*See also* Ex.1101, 4:14-16.) As discussed above, the studs in Jammy are metal electrical contacts. (Ex.1101, 1:34; *see also id.*, 4:32-33; Ex.1097, 28.) Thus, the “quantum conductive barrier layer” in Jammy is an interface layer disposed between and in contact with said source or drain and said metal electrical contact.

e) said source or drain being electrically connected to said metal electrical contact through said interface layer and

Jammy discloses this element. Jammy discloses that “[c]onductive studs 52 and 54 contact diffusions 42 and 44 through quantum conductive barrier layers 56 and 58 respectively.” (Ex.1101, 4:14-16.) Jammy discloses that “[t]he quantum conductive layers of the invention are very thin films of materials which in their bulk properties would be considered dielectrics (i.e., electrical insulators). In very thin layers, however, these materials become electrically conductive.” (*Id.*, 3:23-27; *see also id.*, 3:61-4:1.) Thus, the source/ drain diffusions 42 and 44 are electrically connected to the conductive studs 52 and 54 (i.e., metal electrical contact) through the quantum conductive barrier layer (i.e., interface layer).

f) said interface layer being less than 1 nm thick and comprising an oxide of the semiconductor.

Jammy renders this element obvious. Jammy discloses the interface layer comprising an oxide of the semiconductor. Jammy discloses numerous compounds that can be used for forming the quantum conductive barrier layer. Of particular

relevance are quantum conductive barrier layers formed either with silicon oxynitride or with alumina, as discussed below (Ex.1022, ¶187.):

(1) ***“oxide of the semiconductor”: silicon oxynitride***

Jammy discloses the interface layer comprising an oxide of the semiconductor. Jammy discloses that “[p]referred quantum conductive barrier materials are . . . ***silicon oxynitride***.” (Ex.1101, 3:1-2, 3:51-53.) A POSITA would understand that silicon oxynitride (SiON) is an “oxide of semiconductor.” (Ex.1022, ¶188.) In addition, Jammy discloses another layer that is also an “oxide of semiconductor.” (*Id.*) Jammy mentions that when “an oxynitride quantum conductive layer is desired, the . . . nitrogen reaction process may be conducted with a substrate having a ***pre-existing very thin oxide layer***.” (Ex.1101, 5:41-43.) Because Jammy discloses using a silicon substrate (*id.*, 4:33-36), the oxide layer will be an oxide of semiconductor, and in particular, an oxide of silicon. The pre-existing oxide layer together with the SiON layer will also be an interface layer that comprises an “oxide of semiconductor.” (Ex.1022, ¶188.)

(2) ***“oxide of the semiconductor”: alumina (Al_2O_3)***

Jammy discloses the interface layer comprising an oxide of the semiconductor. In an Final Written Decision for a petition involving U.S. 9,209,261, a patent that has the same specification with the '395 Patent, the Board noted that “we agree with the Petitioner [i.e., Samsung] that Jammy discloses an embodiment in which a ***silicon***

oxide layer exists on the semiconductor surface between the alumina oxide and the source/drain regions of the semiconductor.” (Ex.1116, 31.)

Jammy discloses that “other ceramic materials, such as, for example, *alumina* [Al_2O_3] . . . *may be used*” as quantum conductive materials. (Ex.1101, 3:55-57). Jammy teaches “forming a quantum conductive layer on the exposed surface,” (*id.* at 4:64-65), of a semiconductor substrate, which can be a silicon substrate. (*Id.* at 4:33-36.) Jammy discloses that the fabrication method includes the step of cleaning the exposed silicon surface of the source/drain diffusions using an HF (hydrofluoric acid) solution (Ex. 1101, 4:61-67, Ex.1022, ¶187.) Jammy also mentions that “the quantum conductive layer can be formed by chemical vapor deposition [CVD].” (*Id.*, 6:1-3.)

A POSITA would have been aware, before the alleged priority date of the claims of the '395 Patent, of the process employed to form a layer of *alumina* on the exposed surface of silicon substrate using CVD. (Ex.1022, ¶190.) As Dr. Schubert explains, alumina has been used in semiconductor fabrication at least since the 1970s, and numerous contemporary technical articles in analogous art disclose forming an alumina layer on a silicon surface using CVD. (*Id.*) In view of the disclosure of these articles that Dr. Schubert discusses in detail, a POSITA would know that the deposition of alumina using CVD on a silicon substrate results in formation of a thin layer of silicon oxide directly on the substrate below the alumina layer. (*Id.*)

One such reference is 2002-Stesmans, published in early 2002, that analyzes ultrathin layers of **alumina** on silicon substrate. (Ex.1103, 1957; Ex.1022, ¶191.) In particular, 2002-Stesmans analyzes the interface of silicon with “ultrathin layers of SiO_x , Al_2O_3 and ZrO_2 ” and discloses that “ultrathin layers of Al_2O_3 (~0.5-3 nm) . . . as well as ultrathin SiO_x layer, were deposited at 300°C in an atomic-layer **chemical-vapor-deposition** (ALCVD) reactor using $\text{Al}(\text{CH}_3)_3$ and H_2O . . . as precursors . . . at a pressure of ~1 Torr.” (*Id.* at 1957.) 2002-Stesmans notes that a thin interfacial layer of SiO_x is formed between the silicon and Al_2O_3 (alumina) interface. (Ex.1103, 1959.) In the ALCVD process, such as the one employed by Stesmans, the oxygen precursor H_2O is introduced at the initial stages of the growth process without simultaneous introduction of the aluminum precursor $\text{Al}(\text{CH}_3)_3$. (Ex.1022, ¶191.) As a result, oxygen reacts with the exposed surface of silicon substrate and forms a thin interfacial layer of SiO_x . (*Id.*) According to Dr. Schubert, observations reported in 2002-Stesmans are consistent with the properties of silicon, oxygen and aluminum. (*Id.*) A silicon atom does not bond well with an aluminum atom, but silicon and aluminum atoms bond easily with oxygen atoms. Thus, the oxygen atoms facilitate formation of Al_2O_3 (alumina) layer on a silicon interface by forming a thin interfacial layer of SiO_x . (*Id.*) 2002-Stesmans recommends using a layer of SiO_x with a thickness of about 0.5 nm (5 Å) or more, (Ex.1103, 1959), and discloses forming alumina layers in in range of ~0.5 to 3 nm (5 Å to 30 Å). (*Id.* at 1957; Ex.1022, ¶191.) Thus, 2002-Stesmans teaches a

POSITA how to form an interface layer comprising an “oxide of the semiconductor” where the oxide layer is about 5 Å thick and the alumina layer that is also about 5 Å. The thickness of the resulting stack will be around 10 Å, which is within the most preferred range of 5-15 Å disclosed by Jammy, as discussed below. (Ex.1022, ¶191.)

In light of the disclosure of 2002-Stesmans, a POSITA would also have appreciated the benefits of having a silicon-oxide layer below the alumina layer. (Ex.1022, ¶192.) Citing 1999-Lucovsky (Ex.1108), 2002-Stesmans further states that “it may be also added that model calculations based on constraint theory bear out the *necessity for interposing an ultrathin SiO₂ layer* between the Si substrate and high-κ oxides (Al₂O₃, Ta₂O₅, TiO₂) to attain device grade interfaces.” (Ex. 1103, Stesmans] at 1959; *see also* Ex. 1108, at 1806.) As Dr. Schubert explains, additional several technical articles published in 2001 and 2002 also disclose that deposition of thin alumina (Al₂O₃) films on a silicon substrate using CVD or similar processes results in an ultrathin silicon oxide layer on the silicon substrate below the alumina layer. (Ex.1022, ¶¶193-195; *see also* Ex.1110 (2002-Groner), Ex.1111 (2002-Tsai), Ex.1112 (1975-Raider); Ex.1113 (1997-Cerofolini), Ex.1114 (1983-Mende).)

(3) “less than 1 nm thick”

Jammy renders obvious the interface layer being less than 1 nm thick. (Ex.1022, ¶196.) Jammy discloses that “[t]he quantum conductive layer preferably has a thickness of about 50 Å [5 nm] or less, more preferably about 5-30 Å [0.5-3

nm], ***most preferably about 5-15 Å*** [0.5-1.5 nm].” (Ex.1101, 3:35-37.) Thus, the claimed range overlaps with the range disclosed in Jammy—especially, there is a significant overlap between the claimed range (i.e., less than 1 nm) and the ***most preferred*** range in Jammy (i.e., 0.5-1.5 nm). (*Id.*)

The Federal Circuit has consistently held that “even a slight overlap in range established a *prima facie* case of obviousness” and “such an overlap creates a presumption of obviousness, and that the burden of production falls upon the patentee to come forward with pertinent evidence that the overlapping range would not have been obvious in light of the prior art.” *Genentech, Inc. v. Hospira, Inc.*, 946 F.3d 1333, 1341 (Fed. Cir. 2020) (internal quotations and citation omitted). In *Genentech*, claims to a chemical process operating in a range of temperature below room temperature, “from about 10 °C to about 18 °C” were found to be obvious over a prior art process operating at room temperature, in a range from 18-25 °C, “regardless of the construction of ‘about 18 °C.’” *Id.* at 1337-38, 1341 (citation omitted). In other words, the overlap at a single number, 18 °C, rendered the patent invalid. *See also* MPEP 2144.05 (discussing obviousness of similar and overlapping ranges, amounts and proportions.) Preferred thickness of 0.5-1.5 nm for the quantum conductive layer disclosed in Jammy overlaps significantly with the claimed thickness of “less than 1 nm.” (Ex.1022, ¶196.)

Though Claim 29 requires an interface layer comprising an oxide of the semiconductor to have thickness of less than 1 nm, the '395 Patent discloses that such an interface can have a broad range of thickness. (Ex.1022, ¶197.) The oxide of a semiconductor is employed in the '395 Patent to create a layer that passivates the surface of the semiconductor by removing (or terminating dangling bonds). (*Id.*) According to the '395 Patent, the thickness of an interface layer that includes a passivation layer can be “between approximately 0.1 nm [1 Å] to about 5 nm [50 Å].” (Ex.1001, 10:28-29.) The '395 Patent further mentions that depending upon the implementation, the thickness can be less than 1nm [10 Å], less than 0.5 nm [5 Å] or less than 0.2 nm [2 Å]. (Ex.1001, 10:30-32.) The '395 Patent does not mention that the inventors discovered any unexpected properties of the passivation layer when the thickness is less than 1 nm or any reason why the range of less than 1 nm is “special or critical” to the invention. (Ex.1022, ¶198; *Genentech*, 946 F.3d at 1341.) Passivation layers of thickness less than 1 nm are merely embodiments of the broader range that varies from approximately 0.1 nm to about 5 nm. (Ex.1022, ¶198.)

A person of ordinary skill would have been motivated to retain the thickness of the quantum conductive layer disclosed in Jammy (i.e., the interface layer) to 5-15 Å [0.5-1.5 nm] because Jammy explicitly identifies this range as the *most preferred* range. (Ex.1101, 3:36-38; Ex.1022, ¶199.) In addition, a POSITA would recognize that the thickness of the quantum conductive layer is a process parameter that affects the

result, and is “result-effective.” (*Genentech*, 946 F.3d at 1341; Ex.1022, ¶199). Jammy mentions that the materials employed as quantum conductive layers would “in their bulk properties would be considered dielectrics (i.e., electrical insulators)” but “[i]n very thin layers, . . . these materials become electrically conductive.” (Ex.1101, 1:23-27). A POSITA would be motivated to keep the thickness to the layer in the *most preferred range of 5-15 Å* where the layer is “electrically conductive.” (Ex.1022, ¶199.) As Jammy warns, thicker layers may act like “dielectrics (i.e., electrical insulators)” and increase the overall resistance of the MOSFET 40 disclosed in Jammy. (*Id.*) A POSITA would know that higher resistance in a transistor is an undesirable outcome. (*Id.*)

2. Claim 30

a) The electrical junction of claim 29,

Jammy discloses Claim 29, as discussed in **Section XII.C.1.**

b) wherein the metal electrical contact comprises titanium.

Jammy discloses this element. Jammy discloses that “[t]he invention is not limited to any specific device configuration incorporating the structures of the invention, however, the structures of the invention are preferably incorporated into a MOSFET or other transistor devices.” (Ex.1101, 4:1-4.)

As the Board previously found, Jammy identifies U.S. Patent No. 5,216,282 (“Cote”) (Ex.1099) “as disclosing relevant transistor structures and incorporates

Cote by reference,” and “Cote discloses that ‘titanium, titanium nitride, tungsten, or other appropriate metallurgy’ can be used to form a diffusion contact stud,” i.e., metal electrical contact. (Ex.1097, 28 (citing Ex.1101, 4:5-8 & Ex.1099, 8:24-28).)

As Dr. Schubert notes in his declaration, he has reviewed Ground 2 and has concluded that Jammy renders obvious Claims 29 and 30 of the ’395 Patent. (Ex.1022, ¶¶87, 185-200.)

XIII. THE DISCRETIONARY FACTORS

Petitioners will address discretionary factors per the guidelines provided by the Board. *See* Acting USPTO Director Coke Morgan Stewart, Memorandum, “Interim Processes for PTAB Workload Management” at 2 (Mar. 26, 2025).

XIV. CONCLUSION

Petitioners respectfully request that the Board institute *inter partes* review, hold the Challenged Claims unpatentable, and cancel the Challenged Claims.

Date: May 13, 2025

Respectfully submitted,

By: /Scott C. Weidenfeller/

Scott C. Weidenfeller
Registration No.: 54,531
COVINGTON & BURLING LLP
One CityCenter, 850 Tenth Street, NW
Washington, DC 20001-4956
Telephone: (202) 662-5923
Facsimile: (202) 778-5923
Counsel for Petitioners

CERTIFICATE OF COMPLIANCE

Pursuant to 37 C.F.R. § 42.24(d), the undersigned certifies that the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 10,090,395 contains, as measured by the word-processing system used to prepare this paper, 13,793 words. This word count does not include the items excluded by 37 C.F.R. § 42.24 as not counting towards the word limit.

Date: May 13, 2025

/Scott C. Weidenfeller/
Scott C. Weidenfeller
Registration No. 54,531

CERTIFICATE OF SERVICE

I hereby certify that on May 13, 2025, I caused a true and correct copy of the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 10,090,395 and supporting exhibits to be served on the Patent Owner via in person delivery at the following correspondence address of record as listed on PAIR:

Ascenda Law Group, PC
2150 N First Street
Suite 420
San Jose, CA 95131
Customer No. 27571

A courtesy copy via express mail was also sent at the above mentioned address. A courtesy copy was also sent via electronic mail to Patent Owner's litigation counsel at the following addresses:

Patrick J. Conroy
Ryan P. Griffin
T. William Kennedy Jr.
NELSON BUMGARDNER CONROY PC
2727 N. Harwood St., Suite 250
Dallas, TX 75201
pat@nelbum.com
ryan@nelbum.com
bill@nelbum.com

Stephen B. Brauerman (#4952)
Ronald P. Golden III (#6254)
600 N. King Street, Suite 400
P.O. Box 25130
Wilmington, Delaware 19801

sbrauerman@bayardlaw.com
rgolden@bayardlaw.com

Janson H. Westmoreland
NELSON BUMGARDNER
CONROY PC
3131 W 7th St
Suite 300
Fort Worth, TX 76107
janson@nelbum.com

Date: May 13, 2025

/Scott C. Weidenfeller/
Scott C. Weidenfeller
Registration No. 54,531