

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

INERGY TECHNOLOGY, INC.,
Petitioner

v.

FORCE MOS TECHNOLOGY CO. LTD.,
Patent Owner

Inter Partes Review No. IPR2024-00094
U.S. Patent No. 7,812,409

PATENT OWNER'S RESPONSE
(37 CFR § 42.120)

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Patent Owner's Exhibit List

Exhibit No.	Description
2001	Transcript of Feb. 13, 2024 Deposition of David Kuan-Yu Liu, PhD in <i>Force MOS Technology Co., Ltd. v. ASUSTeK Computer, Inc.</i> , Case No. 2:22-cv-00460-JRG (E.D. Tex.)
2002	Declaration of David Kuan-Yu Liu, Ph.D., served on Jan. 30, 2024 in <i>Force MOS Technology Co., Ltd. v. ASUSTeK Computer, Inc.</i> , Case No. 2:22-cv-00460-JRG (E.D. Tex.)
2003	Defendant ASUSTek Computer, Inc.'s Motion to Stay Pending Resolution of Inter Partes Reviews, filed on Nov. 30, 2023 as Dkt. No. 30 in <i>Force MOS Technology Co., Ltd. v. ASUSTeK Computer, Inc.</i> , Case No. 2:22-cv-00460-JRG (E.D. Tex.)
2004	Amended Docket Control Order, filed on Jan. 18, 2024 as Dkt. No. 35 in <i>Force MOS Technology Co., Ltd. v. ASUSTeK Computer, Inc.</i> , Case No. 2:22-cv-00460-JRG (E.D. Tex.)
2005	Cover pleading to Defendant ASUSTek Computer, Inc.'s Invalidity Contentions, served on Jul. 18, 2024 in <i>Force MOS Technology Co., Ltd. v. ASUSTeK Computer, Inc.</i> , Case No. 2:22-cv-00460-JRG (E.D. Tex.)
2006	U.S. Patent No. 6,700,158 to Cao et al. (issued Mar. 2, 2004)
2007	Excerpts from Webster's New World Dictionary, Third College Ed. (1991) for "square," "substantial," "round," "rounded," and "truncate"
2008	Memorandum Opinion and Order denying Defendant ASUSTek Computer, Inc.'s Motion to Stay Pending Resolution of Inter Partes Reviews, filed on April 11, 2024 as Dkt. No. 74 in <i>Force MOS Technology Co., Ltd. v. ASUSTeK Computer, Inc.</i> , Case No. 2:22-cv-00460-JRG (E.D. Tex.)
2009	--Intentionally Not Used--
2010	--Intentionally Not Used--

Exhibit No.	Description
2011	Claim Construction Order, Dkt. No. 132 from <i>Force Mos Technology Co., Ltd. v. ASUSTeK Computer, Inc.</i> , Case No. 2:22-cv-00460-JRG (E.D. Tex.)
2012	U.S. Patent No. 5,304,831 to Yilmaz et al., “Low on-resistance power MOS technology”
2013	U.S. Patent No. 6,867,083 to Imam et al., “Method of forming a body contact of a transistor and structure there”
2014	Excerpts of Lutz, Josef, et al. "Semiconductor power devices." 2018, ISBN 978-3-319-70917-8 (“Lutz”);
2015	Li, S., & Boyd, J. P. (2015). Approximation on non-tensor domains including squircles, Part III: Polynomial hyperinterpolation and radial basis function interpolation on Chebyshev-like grids and truncated uniform grids. <i>Journal of Computational Physics</i> , 281, 653–668. doi:10.1016/j.jcp.2014.10.035
2016	Maneuski, Dima, V. Gostilo, and A. Owens. "TCAD simulation studies of novel geometries for CZT ring-drift detectors." <i>Journal of Physics D: Applied Physics</i> 53.1 (2019): 015114
2017	Cohen, S. Simon. "Contact resistance and methods for its determination." <i>MRS Online Proceedings Library (OPL)</i> 18 (1982): 361.
2018	Excerpts from Semiconductor Glossary
2019	Ng, Hong Seng. "Review on Methods for Trench MOSFET Gate Oxide Reliability and Switching Speed Improvement." <i>ECS Transactions</i> 27.1 (2010): 21
2020	--Intentionally Not Used--
2021	Declaration of Dean Neikirk, Ph.D. in Support of Patent Owner’s Response
2022	Curriculum Vitae of Dean Neikirk, Ph.D.

Exhibit No.	Description
2023	Transcript of August 6, 2024 Deposition of Sylvia D. Hall-Ellis, Ph.D.
2024	Transcript of August 23, 2024 Deposition of Dr. David Kuan-Yu Liu

Pursuant to 37 C.F.R. § 42.120, Patent Owner Force MOS Technology Co. Ltd. (“Patent Owner” or “Force MOS”) hereby submits its Patent Owner Response.

I. INTRODUCTION

Petitioner presents two main sets of grounds: (i) those with Kobayashi alone as the primary reference (grounds 1-3) and (ii) those combining Kobayashi with Hshieh (grounds 4-6). As to the first set of grounds, Petitioner presents two theories, both of which are plainly meritless. First, Petitioner argues that hexagons are actually “substantially square shaped cells with rounded corners.” To do so, Petitioner ignores that squares have four sides, not six, and relies on a construction that a District Court has already rejected—requiring “rounded corners” to mean “corners that are truncated by design layout and then rounded.” In Petitioner’s alternative theory, it argues the same limitation is satisfied by Kobayashi’s rounding of the *gate trench*’s openings and closings (which are visible in the side view). But that disregards that the claim limitation requires the substantially square-shaped *cell*, not the gate trench, to have rounded corners, and the corners of a square-shaped cell are only visible in the top view.

As to the set of grounds where Petitioner combines Kobayashi with Hshieh, Petitioner’s obviousness argument is plainly inadequate and the result of hindsight bias. The ’409 Patent is directed to a novel combination of cell features for a power MOSFET—square shaped cells with truncated or rounded corners and a circular

trenched contact—that together result in increased uniformity between the gate trench and the circular contact, thereby improving avalanche ruggedness. Petitioner’s combination achieves that result only via the unexplained and arbitrary selection among different embodiments of Kobayashi and Hshieh, including; (1) Kobayashi’s square-gird cell embodiment; (2) Kobayashi’s circular contact hole shape embodiment; (3) Kobayashi’s trench-gate trench-source MOSFET structure instead of Hshieh’s vertical-draining double diffused MOSFETs or trench gate MOSFETs without trenched source contacts; and (4) Hshieh’s embodiments with all corners rounded. This arbitrary combination also ignores the important differences between the references and the claimed invention. Hshieh discloses no trenched source contacts, describes no trench-gate embodiments with rounded or blunted corners, and expressly teaches away from square-based cell topologies. Instead, Hshieh is focused on the need to round or blunt the corners of its non-orthogonal polygon cells due to the effect of the “three dimension diffusion phenomenon” on sharp corners of its design, which can risk punch-through.

And, despite it being their primary motivation to combine theory, Petitioner fails to explain how or whether the three dimension diffusion phenomenon affects Kobayashi. Indeed, as the Yilmaz patent cited in Hshieh explains, the three-dimensional diffusion problem relates to differences in the *horizontal* displacement of p-type and n-type dopants in cell corners. Thus, it has no effect on Kobayashi’s

vertical channel and *vertically* defined interfaces between dopant regions. Petitioner tries to suggest there was some generally “known” benefit of rounded corners in MOSFETs. To do so, Petitioner improperly conflates the teaching side-view rounding of trench corner bottoms and openings with Hshieh’s unrelated cell corner rounding. But these are different types of rounding, for different purposes, in different locations.

Petitioner’s theories for several dependent claims also fail. In particular, as to claim 5, Petitioner’s attempts to construct a disclosure or suggestion of a specific numeric limitation by improperly trying to discern measurements from Kobayashi’s figures, which are not described as being to scale. As to the Kikkawa grounds (grounds 3 and 5), Petitioner attempts to combine unrelated teachings from a different field—DRAM interconnects—that have nothing to do with the specific structural uses of titanium in conjunction with metal plugs in the MOSFET of claims 2 and 6. Moreover, Petitioner’s argument that Kikkawa was a printed publication as of the priority date improperly depends on an uninvolved witness’s mere searches of public databases, rather than anyone with personal knowledge regarding its publication or regarding the accuracy of the systems that allegedly have the relevant publication records.

For all of these reasons, the Board should hold that all challenged claims are patentable.

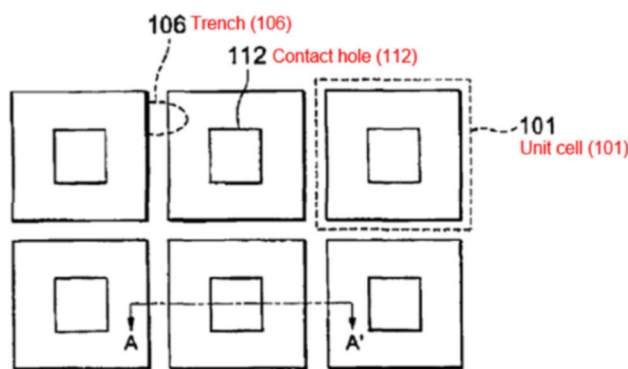
II. OVERVIEW OF THE '409 PATENT

The '409 Patent relates to improved cell layouts for trench MOSFETs. Ex. 1001 (“'409 Patent”), Abstract. Prior art cell layouts for trench MOSFETs—which used conventional square shaped cells with square shaped contacts—had a problem. *Id.*, Fig. 1A. In particular, “parasitic bipolar NPN latch up”—a type of undesired current flow—was especially pronounced near the cells’ corners in prior art devices. *Id.*, 1:15-20; Ex. 2021 ¶72. The '409 Patent recognized that this problem was exacerbated by the significant variation in the distances between the contact and the gates in prior art, where the distances at the corners of the trench gate would be over 1.4 times farther from the source contact than the same measurement at the middle of the sides of the trench gate. '409 Patent, Fig. 1A, 1:28-39. As a result, the non-uniform space between the square-shaped contact and the corners of the gate trench creates weak points, resulting in low avalanche current and reduced device ruggedness. *Id.*, 1:45-57. The '409 Patent addressed this problem by introducing an improved cell layout, having a circular contact and rounded or truncated corners to make the space between the trenched gate and the source contact more uniform, thereby enhancing device ruggedness. *Id.*, 2:3-7, Abstract, Figs. 2, 3, cls. 1, 6.

III. OVERVIEW OF THE ASSERTED PRIOR ART

1. U.S. Patent No. 6,888,196 (“Kobayashi”)

Kobayashi is entitled “Vertical MOSFET Reduced in Cell Size and Method of Producing the Same.” It discloses MOSFETs using conventional cell layouts, such as square cells with square corners and square contacts. Ex. 1005, Fig. 3A; Ex. 2021 ¶103.



Annotated version of Kobayashi's Fig. 3A from Ex. 1003 ¶67

Although Kobayashi refers to “rounding,” it does not disclose rounding of the corners of a MOSFET cell, which are shown—unrounded—in the above top view image of Fig. 3A of Kobayashi. Rather, Kobayashi's rounding is directed to the rounding of the trenches' opening and bottoms (which are visible in the side view). Ex. 1005, 7:57-59; Ex. 2021 ¶104. Thus, Kobayashi's Figure 6C, a sectional side view (not a top view), shows only the trench bottoms as rounded—not the corners of the closed cell, which are visible from a top view:

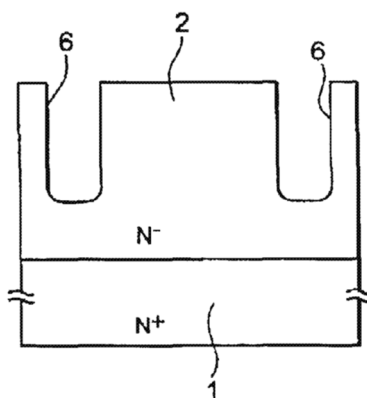


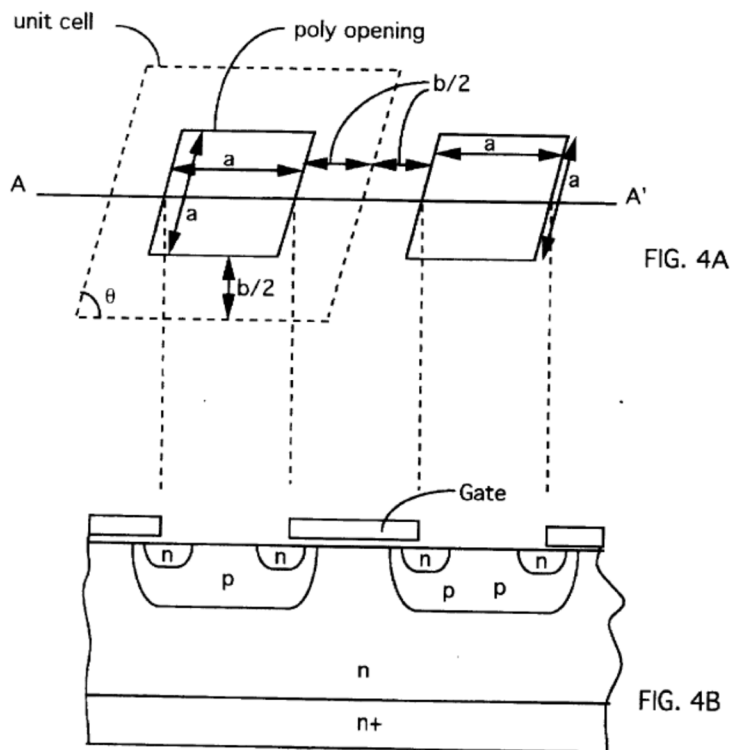
FIG. 6C

2. U.S. Patent No. 5,763,914 (“Hshieh”)

Hshieh is entitled “Cell Topology for Power Transistors with Increase Packing Density.” It discloses a MOSFET cell topology where packing density is increased by arranging cells as non-orthogonal parallelograms compared with that of conventional square cells. Ex. 1006, 2:64-3:5, Figs. 4A, 4B. Unlike the ’409 Patent which has both “trenched gates” and a “circular [source] trench contact,” most of Hshieh embodiments lack “trenched gates,” and none of them have trenched source contacts. Ex. 1006, 4B, 9D, 10B, 7:26-8:5; Ex. 2021 ¶106. And, of the embodiments disclosed and described in Hshieh that do have trench gates, they all lack rounded or blunted corners. *Id.* In each of Hshieh’s embodiments, rather than having source metal connected to a metal-filled trench penetrating into the semiconductor material’s source and body regions, the source metal instead is in a planar relationship with the underlying semiconductor material and contacts that semiconductor material through “source openings” in the oxide layer. Ex. 1006,

Figs, 4B, 9D, 10B, 1:45-51, 3:38-42, 6:52-56, 7:2630, 7:56-60, cl. 21; Ex. 2021

¶106.



Ex. 1006, Figs. 4A, 4B

Accordingly, Hshieh's discussion of "rounding" is not concerned with problems relating to the distance between a trenched source contact and a gate trench.

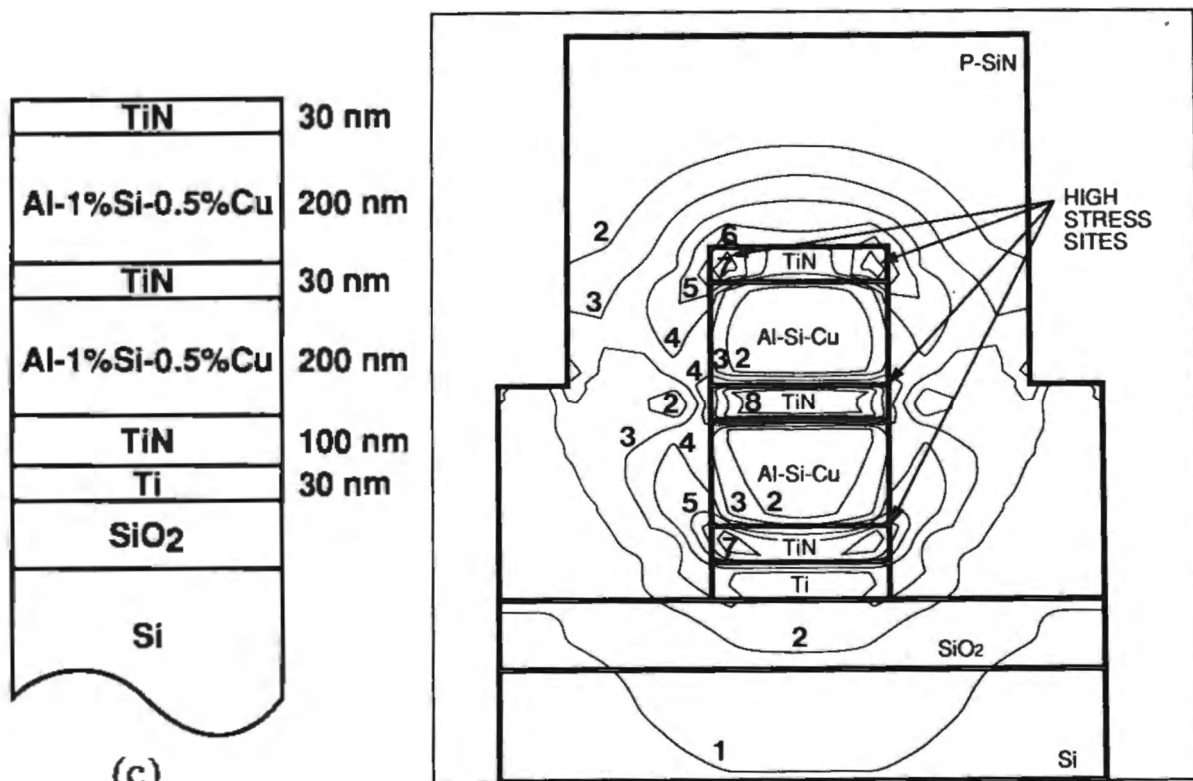
Rather, Hshieh is concerned with the effect of the "three dimension diffusion effect," which are particularly significant at the two sharper corners of Hshieh's non-orthogonal parallelograms. Ex. 1006, 2:19-34, 5:3-17; Ex. 2021 ¶¶105-106. Hshieh cites to U.S. Patent No. 5,304,831 to Yilmaz (Ex. 2012) as explaining the three-dimensional diffusion effect. Ex. 1006, 2:19-34. Yilmaz explains that that the three-dimensional diffusion phenomenon arises in vertical draining double diffusion

MOSFETs, where p-type dopants (used in the body region of n-type MOSFET) diffuse horizontally by significantly less in corners than n-type dopants (used in the source and drain regions of n-type MOSFETs). Ex. 2012, 3:42-4:1. Because double diffusion MOSFETs have horizontal channels, this results in a shorter channel and punch-through at the corners. *Id.*, 4:1-11, Fig. 4 (element 44); Ex. 2021 ¶150. Thus, Yilmaz and Hsieh both propose using corner rounding or blunting to alleviate the problem of short channels in the corners that can arise in double diffused MOSFETs due to the three-dimensional diffusion effect. Ex. 2012, 4:12-28; Ex. 1006, 2:24-34, 5:3-8.

3. Kikkawa

Kikkawa is an article on the article entitled “A Quarter-Micrometer Interconnection Technology Using a TiN/Al-Si-Cu/TiN/Al-Si-Cu/TiN/Ti Multilayer Structure,” purportedly published in IEEE Transactions on Electron Devices, Vol. 40, No. 2.” Ex. 1007. Petitioner relies on Kikkawa as a secondary reference for certain limitations of claims 2 and 6 which recite specific uses of titanium in connection with the contact metal plug. Pet., 4, 36-41, 63-67. Kikkawa is directed to “multilayer conductor” as “a quarter-micrometer interconnection for 256-Mb DRAM’s. Ex. 1007, 3. In particular, Kikkawa is concerned with the problem of electro-migration and stress-migration in existing DRAM aluminum alloy interconnects. *Id.*; Ex. 2021 ¶¶108-109. Kikkawa tested a mockup of a

“conductor”—a structure for connecting metal interconnect layers within DRAM—using alternating layers of aluminum alloys and titanium / titanium alloys to address the problems of electro-migration and stress-migration. Ex. 1007, 3, 7, Fig. 11.



(c)
Ex. 1007, p. 4, Fig. 1(c)

Ex. 1007, p. 7, Fig. 11(b)

IV. LEVEL OF ORDINARY SKILL IN THE ART

Petitioner argues that a person of ordinary skill in the art (“POSITA”) would have “have a master’s degree in electrical engineering, and at least two years of relevant work experience in the field of integrated circuit design and manufacturing.” Pet., 13. For the purpose of this proceeding, Patent Owner does not dispute that characterization. Ex. 2021 ¶55.

V. CLAIM CONSTRUCTION

A. “substantially square-shaped cells with rounded corners” (cl. 1)

As explained below, this term should receive its plain and ordinary meaning, i.e.: the cells have, from the top view perspective, largely or essentially the shape of a square (a shape that has four equal sides and four right angles) with all of the cell’s corners rounded (i.e. having a curved shape like a portion of a circle or oval).

1. Petitioner’s “design layout” construction of “rounded corners” should be rejected

“Rounded corners” simply means that the “substantially square-shaped cells” have corners that are corners that are round, i.e. having a curved shape like a portion of a circle or oval. Ex. 2007, 5 (“round”: “3 curved in shape like part of a sphere or circle ... n. 1 something round or rounded; thing or part that is spherical, globular, circular, curved, annular or cylindrical”); *see also* ’409 Patent, Fig. 3, 4:4-9 (describing Fig. 3 as embodiment with “rounded corners” for gate trenches, and depicting a square with curved corners).

Ignoring this ordinary meaning, Petitioner proposes that “rounded corners” be construed as “corners that are truncated by design layout and then rounded.” Pet., 15. Petitioner does seek an express construction of the remainder of this limitation, but in grounds 1-3, Petitioner applies “substantially square-shaped cells with rounded corners” against hexagons and squares with standard, sharp corners. Pet., 26. In particular, Petitioner argues that hexagons are essentially squares because one

can visualize the geometry of hexagons as being created by cutting off large portions of squares. *Id.* Petitioner provides no plausible basis for deviating from this term’s plain and ordinary meaning. Indeed, as a District Court held in rejecting the same construction proposed by real-party-in-interest ASUSTek, “the term ‘rounded corners’ in Claim 1 is directed to what ‘rounded corners’ are, not how the ‘rounded corners’ were made.” Ex. 2011, 30, 32.

Thus, this term should receive its plain and ordinary meaning, *i.e.*: the cells have, from the top view perspective, largely or essentially the shape of a square (a shape that has four equal sides and four right angles) with all of the cell’s corners rounded (*i.e.* having a curved shape like a portion of a circle or oval). A square is a shape with four sides of equal length and four right angles. Ex. 2007, 6. “Substantially square shaped cells” refers to cells having largely or essentially the shape of a square. Indeed, it is well established that the patent claim term “substantially” (as used in this context) is a term of approximation that means “largely” or “essentially.” *Clare v. Chrysler Grp. LLC*, 819 F.3d 1323, 1330 (Fed. Cir. 2016); *Deering Precision Instruments, L.L.C. v. Vector Distribution Sys., Inc.*, 347 F.3d 1314, 1323 (Fed. Cir. 2003); Ex. 2007, 7 (“substantial”: “7 with regard to essential elements”).

Petitioner’s arguments fundamentally misconstrue this claim term and ignore the clear teachings of the specification of the ’409 Patent. The ’409 Patent discloses

two distinct embodiments: cells with “truncated corner[s]” and cells with “rounded corner[s].” ’409 Patent, 1:66-2:7. Figure 2 is an “improved cell layout” where the “trenched gate 100 [] has [] truncated corners.” *Id.*, 3:17, 3:32-35. And, correspondingly, claim 6 recites “said trenched gates surrounding said transistor cells as closed cells constituting substantially square-shaped cells with *truncated corners*.” *Id.*, cl. 6 (emphasis added). By contrast, Figure 3 is “another embodiment of this invention wherein a closed cell unit 200 of a MOSFET device includes trenched gate 210 ... and the trenched gate is formed with rounded corners 215.” *Id.*, 4:4-9. Similarly, claim 1 recites “trenched gates surrounding said transistor cells as closed cells constituting substantially square-shaped cells with *rounded corners*.” *Id.*, cl. 1 (emphasis added); Ex. 2021 ¶84; Ex. 2011, 29-30.

Despite these teachings, Petitioner’s construction conflates these embodiments, arguing that both “truncated” and “rounded” corners must begin with a “truncated” “design layout” and that “rounded corners” are thereafter “rounded.” Pet., 15-18. They point to the ’409 Patent’s specification statements that “[t]he truncated corners are formed by design layout not process” and “[i]t is by nature that truncated corners in layout becomes rounded after exposure due to resolution issue of 0.18~0.35 μm photolithography.” ’409 Patent, 2:17-20; *see also id.*, 4:57-62; *see also id.*, 2:14-17, 2:58-60. But nothing in this statement represents a clear and unmistakable disclaimer relating to the design of a MOSFET with “rounded

corners.” *See Thorner v. Sony Computer Entertainment America LLC*, 669 F.3d 1362, 1367 (Fed. Cir. 2012). To the contrary, all of Petitioner’s cites are passages that discuss the “process for manufacturing” or “manufacturing process.” ’409 Patent, 2:10-20, 4:53-62. Nothing in claim 1 of the ’409 Patent—which is an apparatus claim—indicates that it is limited to products made by a particular process. *Id.*, cls. 1, 6; *See, e.g., Cont’l Cirs. LLC v. Intel Corp.*, 915 F.3d 788, 799 (Fed. Cir. 2019) (“Generally, a novel product that meets the criteria of patentability is not limited to the process by which it was made.”) (cleaned up); Ex. 2011, 30; Ex. 2021 ¶¶86-87. Nor does the background knowledge of a POSA compel Petitioner’s construction. Indeed, Petitioner’s expert has admitted that rounded corners can be created by rounded corners in a mask design layout—contrary to Petitioner’s construction. Ex. 2001, 143:16-21.

Finally, Petitioner argues that its construction is compelled by the prosecution history where the patentee distinguished the Pfirsch reference. Pet., 17. But the patentee never distinguished Pfirsch on the basis of the “rounded corner” limitation. Indeed, the patentee expressly admitted that “Pfirsch [] has a closed cell with square trench gate with rounded corner.” Ex. 1002, 302. Instead, the patentee distinguished Pfirsch as having a “square contact with rounded corner,” i.e. that it lacked the claimed “circular trench.” *Id.*; *see also id.*, 295 (in same office action response, amending claim to recite “circular trench contact hole”). Thus, there is no clear and

unmistakable disclaimer of rounded corners created by processes other than truncating in design layout and then rounding.

2. The “rounded corners” are those of the cell—which are visible in the top view—not the corners of the trench gate visible in the side view

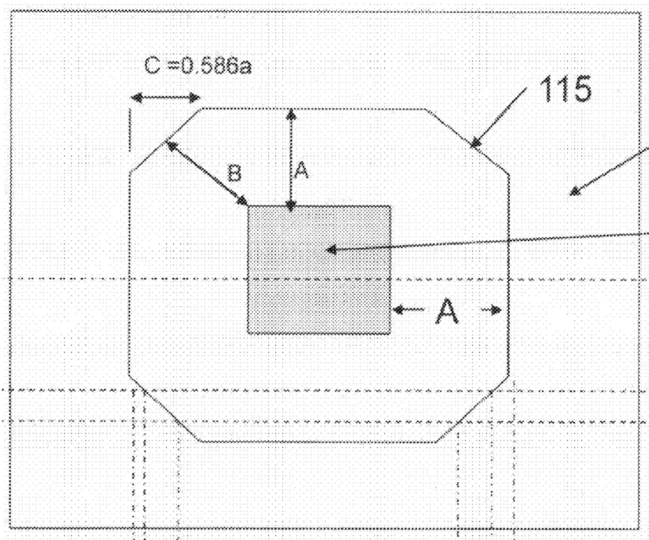
Another claim construction dispute arises from Petitioner’s argument that the “rounded corners” need not be the actual corners of a square-shaped cell, but rather can be satisfied by rounding of the gate trenches’ bottom corners and openings (which are visible in a side view cross-section of the cell). Pet., 27.

This argument is contradicted by the plain language of the claim, which recites “trenched gates surrounding said transistor cells as closed cells constituting substantially square-shaped **cells with rounded corners.**” ’409 Patent, cl. 1 (emphasis added). Thus, although both the “trenched gates” and the “cells” are recited in this limitation, it is the “square-shaped cells” that have the “rounded corners,” not merely the trenched gates. Ex. 2021 ¶88. If there were any ambiguity here—there is not—it is resolved by application of the “last antecedent” rule, which provides that a qualifying clause (i.e. “with rounded corners”) refers to the immediately preceding words or phrases (i.e. “substantially square-shaped cells”). *See Finisar Corp. v. DirecTV Grp., Inc.*, 523 F.3d 1323, 1336 (Fed. Cir. 2008).

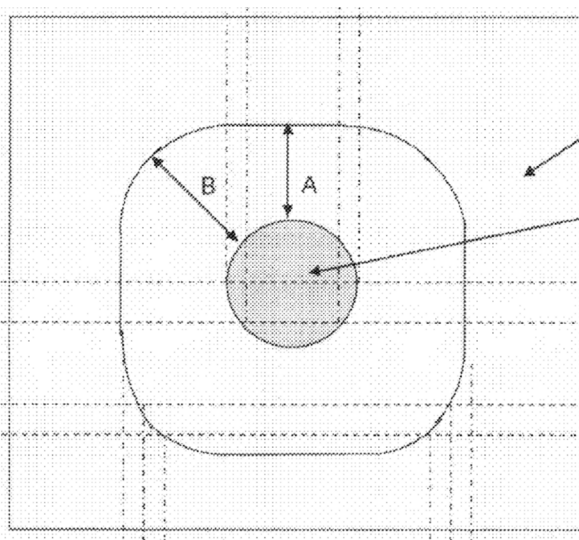
That the “rounded corners” have to be those of the square-shaped cells (visible from the top view) is also reinforced by the specification of the ’409 Patent. Ex.

2021 ¶¶89-90. It states that prior art “FIG. 1A” provides “a top view of a closed cell unit” which “illustrate[s]” “a square cell configuration and the shortest distance between the peripheral sides of the metal contact 15 to the trenched gates is longer from the corner of the metal contact 15 to the corner of the trenched gates.” ’409 Patent, 1:20-33; *see also* 3:12-16 (describing Fig. 1A as a “top view ... illustrating a configuration cell layout of a closed cell unit of a MOSFET device with non-uniform space between the metal contact the trenched gates surrounding the closed unit cells.”). These distances “play[] an important role in determining device ruggedness” and that such “non-uniform spac[ing]” means that “weak points occur at the four corners that result in low avalanche current and reduced device ruggedness.” *Id.* 1:45-53.

The ’409 Patent then introduces an improved “close cell unit configuration with the surrounding gate arranged with truncated corner or rounded corner **layout**.” *Id.*, 1:66-2:3 (emphasis added). In the disclosed embodiments, these truncated or rounded corners are visible in the top-view layout of the cells:



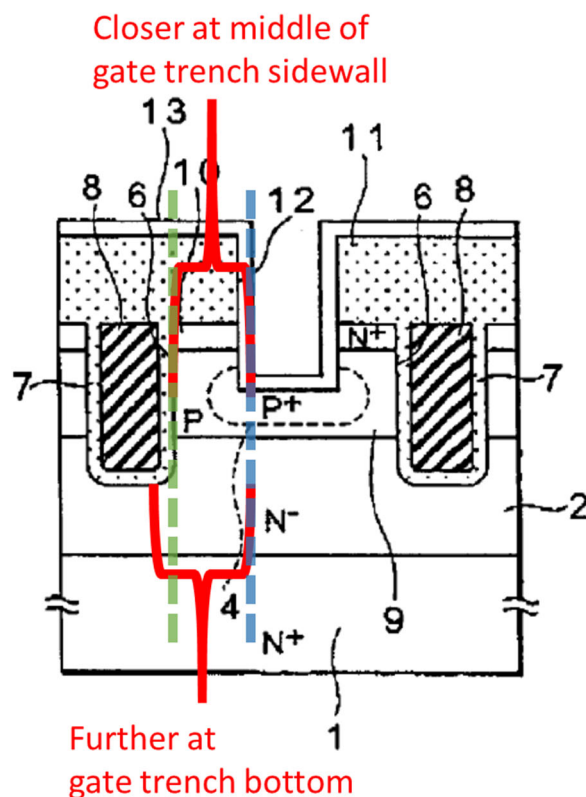
'409 Patent, Fig. 2 (cropped)



'409 Patent, Fig. 3 (cropped)

Figure 2 is “a top view of a closed cell configuration of an improved semiconductor power device 100 of this invention” where “[t]he closed cell is surrounded by a trapezoidal gate 110 that has truncated corners 115” and thus “[t]here is a uniform space between the surrounding trapezoidal gate 110 and the metal contact ... [and] [t]he weak spots around the corners in a conventional layout are therefore eliminated.” *Id.*, 3:32-43. Figure 3 is “another embodiment of this invention wherein a closed cell unit 200 of a MOSFET device” where “the trapezoidal gate is formed with rounded corners 215.” As a result, “[t]he distance B to the rounded corners 215 and to the distance A to the edges of the trapezoidal gate are substantially the same” and thus “[t]he weak spots near the corners of the trapezoidal gate that caused reduced device ruggedness are therefore eliminated.” *Id.*, 4:4-17.

Thus, the '409 Patent shows that the relevant “rounded corners” or “truncated corners” are those of the cell’s layout, which are visible in the top view, as illustrated in Figs. 2 and 3. Indeed, the primary purpose of the '409 Patent—improved uniformity of spacing between the trenched source contact and the gate trenches—is not served by rounding of trench bottom corners or openings visible in the side view. '409 Patent, 1:18-57, 1:66-2:7; Ex. 2021 ¶¶90. As shown, side-view rounding of *trench* tops and bottoms (such as in in Kobayashi) makes that space *less uniform*, as shown in Kobayashi’s figures after the source trench has been etched:



Ex. 1005, Fig. 7D (annotated)

Ex. 2021 ¶¶90, 113.

The prosecution history also demonstrates that the relevant corners are those of the cell, which are visible in the top view. In a July 15, 2009 rejection, the examiner rejected the claims over a combination including the Imam reference (U.S. Patent No. 6,867,083, Ex. 2013). The examiner stated that Imam discloses “a plurality of substantially square-shaped cells,” and cited to, among other things, Imam’s Figure 6. Ex. 1002, 277. Fig. 6 of Imam illustrates that the square cells exist in the top view perspective. Ex. 2013, 5:35-39, Fig. 6; Ex. 1002, 279; Ex. 2021 ¶91. Similarly, the asserted prior art references also use the top view perspective to depict square shaped cells and their corners. Ex. 1005, 6:25-35, Figs. 3A, 3B, 4A and 4B; Ex. 1006, 4:1-3, 4:32-38, Figs. 4A and 4B; Ex. 2021 ¶92. Thus, all of the intrinsic evidence and other contemporary evidence demonstrates that the “rounded corners” must be those of the “substantially square-shaped cell” (visible from the top view), rather than merely the gate trench’s bottom corners and openings (visible from the side view).

Moreover, Petitioner’s argument using side-view rounding is entirely inconsistent with its “design layout” construction—the design layout only controls the top view perspective of the cell. Ex. 2021 ¶ 93.

3. All of the square shape’s corners must be rounded

Finally, this claim term requires that all four corners of the essentially square-shaped cell be rounded. As discussed above, the structure that has the “rounded

corners” is the cell. Thus, “substantially square-shaped cells *with rounded corners*” means that all of the square’s four corners are rounded. The claim uses no language suggesting that non-rounded corners are permitted, which the patentee could have readily recited instead (e.g. “with at least some rounded corners”). Ex. 2021 ¶94. Additionally, a POSITA would understand that the concept of a square with rounded corners consistently refers to a square with all corners being rounded. Square shapes with rounded corners are consistently depicted in the art as having all four corners rounded. *Id.*

Similarly, the ’409 Patent consistently depicts and describes only embodiments with all corners rounded. *See, e.g.,* ’409 Patent, Fig. 3 (illustrated all four corners of square being rounded). Indeed, permitting some corners to not be rounded would be entirely inconsistent with the purpose of the rounded corners: to make the distance between the trench gates and the source contact metal more *uniform*. *Id.*, 2:3-7. Having some but not all corners of the cell be rounded would only increase non-uniformity. Ex. 2021 ¶95.

B. “substantially square-shaped cells with truncated corners” (cl. 6)

As with the prior term, Petitioner provides no plausible basis for deviating from the plain and ordinary meaning. Thus, this term should receive its plain and ordinary meaning: the cells have, from the top view perspective, largely or

essentially the shape of a square (a shape that has four equal sides and four right angles) with all of the cell's corners truncated (i.e. being cut off).

The appropriate construction of this term is readily apparent for the same reasons discussed in the prior term. *See supra* V.A. A square is a shape with four sides of equal length and four right angles. Ex. 2007, 6. Substantially square shaped cells refers to cells having largely or essentially the shape of a square. Ex. 2007, 7. Truncated corners simply means that the substantially square-shaped cells have corners that are cut off. Ex. 2007, 8 (“truncate”: “to cut off a part of; shorten by cutting”); *see also* ’409 Patent, Fig. 2, 3:34-39, 3:55-61 (describing Fig. 2 as embodiment with “truncated corners” for gate trenches, and depicting a square with corners that have been cut off). And, as discussed, the patent and prosecution history makes clear the relevant perspective for the cells is the top view, and all the corners have to be truncated. ’409 Patent, Figs. 2-3, 1:18-57, 1:66-2:7, 3:32-45, 3:55-4:3, 4:9-20, 4:33-51.

Petitioner’s “design layout” arguments fail here for the same reasons that they do for the previous claim term. *See supra* V.A.1. In particular, Petitioner points to language in the specification describing methods by which embodiments of the invention *can* be manufactured, but does not identify any language of manifest exclusion or restriction that would disclaim other methods of manufacturing the claimed apparatus. Pet., 19 (citing ’409 Patent, 2:10-20; 4:53-64). Nothing in the

claims or specification limits the apparatus claim 6 to being manufactured in a particular way. Ex. 2021 ¶100. Indeed, Petitioner’s arguments are even worse as to this limitation, because the portions of the specification that they point describe a way for making a MOSFET with rounded corners, not “truncated corners.” Petitioner does not explain how their constructions for “rounded corners” and “truncated corners” respects the patentee’s choice to recite different terms in different claims. Ex. 2021 ¶100; *Bd. of Regents of the Univ. of Texas Sys. v. BENQ Am. Corp.*, 533 F.3d 1362, 1371 (Fed. Cir. 2008) (“Different claim terms are presumed to have different meanings”).

Petitioner’s prosecution history argument also fails. Petitioner cites to a generic statement in the prosecution history where the patentee explained that a long list of newly amended limitations had section 112 support, only one of which was “truncated corners.” Pet., 19 (citing Ex. 1002, 302). However, none of the cited statements rise to the level of clear or unmistakable disclaimer that would justify Petitioner’s rewriting of this limitation—nothing mentions Petitioner’s “design layout” limitation. Ex. 1002, 302. Similarly, to the extent that Petitioner is attempting to apply their arguments about Pfirsch (which they discuss regarding “rounded corners”) to this limitation, that argument fails for the same reasons discussed above. *See supra* V.A.1. Indeed, the cited portion of the file history does

not even mention truncated corners in relation to Pfirsch. Ex. 1002, 302; Ex. 1011, Fig. 2.

VI. PETITIONER HAS FAILED TO DEMONSTRATE ANY OF THE CHALLENGED CLAIMS ARE UNPATENTABLE

A. Ground 1: Kobayashi Fails to Anticipate Claims 1 or 3-5

1. Claim 1

- (a) Kobayashi Fails to Disclose element 1[a]: “said trenched gates surrounding said transistor cells as closed cells constituting substantially square-shaped cells with rounded corners”**

Petitioner presents two apparent theories for this limitation: (1) the hexagonal cells of Kobayashi’s Figure 4A are “substantially square cells with truncated corners;” and (2) the combined disclosures of the square cells of Kobayashi’s Fig. 3A and the “rounding” of Kobayashi’s trench corners and openings, visible from the side view. Pet., 25-27. Each of these theories fails.

(1) Petitioner’s “hexagon” theory fails—hexagons are not square-shaped

Petitioner’s argument regarding the hexagons of Kobayashi’s Figure 4A plainly fails. This limitation requires “closed cells constituting substantially **square**-shaped cells with rounded corners.” ’409 Patent, cl. 1 (emphasis added). However, Figure 4A of Kobayashi depicts conventional, regular hexagons with sharp corners, which a POSITA would understand as hexagonal shaped cells, not substantially

square-shaped cells. Ex. 2021 ¶111 (discussing Ex. 1005, Fig. 4A). Such hexagons have six sides of equal length, not the four sides of equal length of a square. *Id.*

Petitioner argues that such hexagons are nonetheless “substantially square cells with truncated corners.” Pet., 26. But, this invokes Petitioner’s erroneous claim construction which, as discussed above (*supra* V.A.1), improperly conflates “truncated” and “rounded.” Moreover, such “truncation” lacks any factual basis—nothing in Kobayashi mentions truncating any squares. Ex. 2021 ¶111. And, Petitioner’s own figures demonstrate that creating a hexagon from a square would require cutting off far more than just the corners—two of the sides of the hypothetical square would be rendered into mere points. *Id.*; Pet., 53 (annotating Kobayashi, Fig. 4A). In short, a hexagon is not essentially square shaped and truncated corners are not rounded corners.

(2) Petitioner’s rounding of trench bottoms and opening—visible from the side view—is not “rounded corners” of “substantially-square shaped cells”

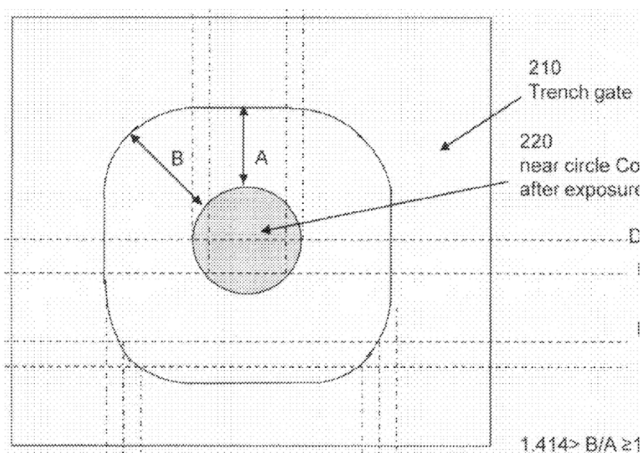
Petitioner’s other theory invokes Kobayashi’s disclosure of rounding the “bottom” corners and “opening” corners of the “trench 6” (Kobayashi’s gate trenches). Pet., 27 (citing 7:57-8:4). However, as discussed above, the appropriate construction of “closed cells constituting substantially square-shaped cells with rounded corners” requires that the square-shaped *cells’ corners* be rounded, not simply any corners of the gate *trench*. *Supra* V.A. Kobayashi’s disclosure of

rounding in column 7 and 8 plainly are directed to rounding the corners of the *trench*, not the corners of a square-shaped cell.

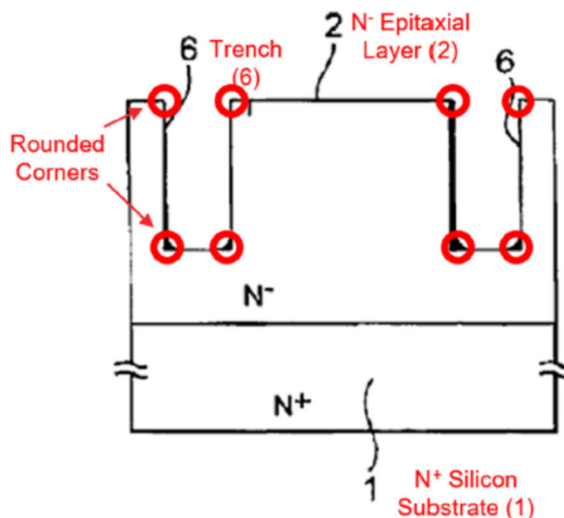
Next referring to FIG. 6C, after the composite film is removed by etching, **corners of each trench 6 at the bottom are rounded**. In this event, **corners of each trench 6 at an opening portion may also be rounded**.

Ex. 1005, 7:57-60 (emphasis added).

Thus, plainly what Petitioner relies on is not rounded corners of “substantially square-shaped cells” (i.e. rounding visible from the top view) but rather rounding of *corners* of the gate (i.e. side view rounding). Ex. 2021 ¶112. This distinction is illustrated by comparing Petitioner’s annotated version of Fig. 6C of Kobayashi to Fig. 3 of the ’409 Patent:



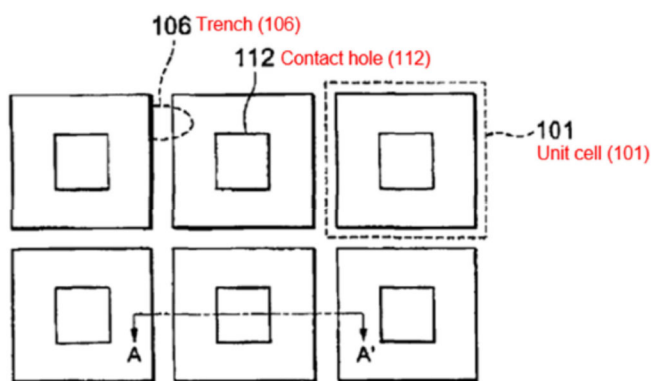
'409 Patent, Fig. 3 (cropped)



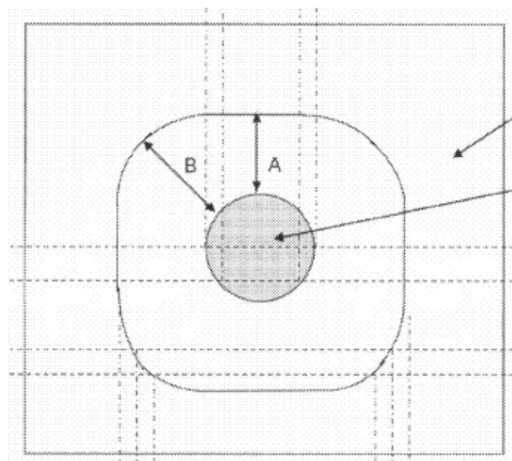
Pet., 27 (Annotating Ex. 1005, Fig. 6C)

As shown, the corners that Petitioner is identifying as rounded are not the corners of a square-shaped cell—there is nothing square shaped is visible in Fig. 6C

of Kobayashi. By contrast Fig. 3 of the '409 Patent shows a clear shape of a substantially square shaped cell with rounded corners. This is also confirmed, when one looks Kobayashi's square cells: they plainly depict conventional square shapes without rounded corners, unlike the '409 Patent's rounded corner embodiment:

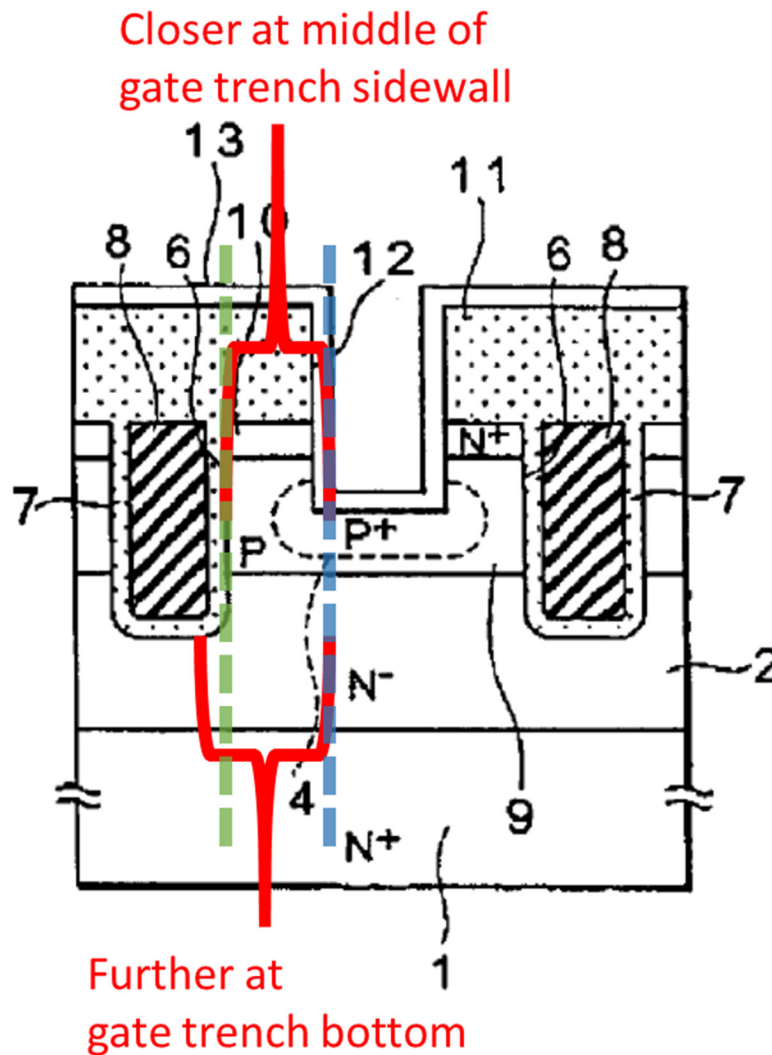


Pet., 52 (annotating Ex. 1005, Fig. 3A)



'409 Patent, Fig. 3 (cropped)

This distinction is also emphasized by examining the purpose of the rounded corners in the '409 Patent: “[t]he purpose of the truncated corners or the rounded corners of the gate trenches is to **make the space between the trenched gate and the metal contact more uniform** in the closed cell to enhance the device ruggedness.” ’409 Patent, 2:3-7. However, the side-view rounding of *trench* tops and bottoms in Kobayashi makes that space *less uniform*, as shown in Kobayashi's figures after the source trench has been etched:



Ex. 1005, Fig. 7D (annotated)

Ex. 2021 ¶¶90, 113.

Petitioner’s argument is also inconsistent with the structure of the claim language, which recites, “said ***trenched gates surrounding said transistor cells as closed cells*** constituting substantially square-shaped cells with rounded corners.” Viewed from a side view perspective—as Petitioner’s “rounded corner” theory requires—Kobayashi’s gates do not ***surround*** the bottom of the source and body

regions—the bottom of the body regions in the side-view cross-section of Kobayashi’s Fig. 6C contact the N+ substrate layer. Ex. 1006; Fig. 6C. Pet., 27 (citing Ex. 1005, 7:57-8:4). Ex. 2021 ¶114. In short, the side-view corners are not the corners of the square-shaped cell because no square is visible in the side-view. And, as discussed above, Petitioner’s side view rounding theory is entirely inconsistent with Petitioner’s proposed construction of “rounded corners” requiring that the claimed rounding must be a result of “truncating” in the design layout. *Supra* V.A.2; Ex. 2021 ¶¶93, 115.

In short, Petitioner’s argument would essentially rewrite the “rounded corners” limitation as simply requiring that the gate trenches have *some* rounded corners *somewhere*. But the claim requires “substantially square-shaped *cells with rounded corners*,” which Kobayashi plainly lacks.

2. Claims 3-5

Claims 3-5 depend from claim 1. ’409 Patent, cls. 3-5. Petitioner’s arguments in ground 1 for alleged anticipation of claims 3-5 are based on Petitioner’s anticipation arguments for claim 1, which fail as discussed above. Pet., 33-35; *see supra* VI.A.1.a. Thus, Petitioner has not demonstrated that claims 3-5 are anticipated. Ex. 2021 ¶¶116-117.

3. Claims 5:

- (a) Kobayashi Fails to Disclose claim 5: “a diameter of a top surface of said circular trench contact is smaller than 1.0 micrometer”**

Claim 5 depends from claim 1 and further recites, “a diameter of a top surface of said circular trench contact is smaller than 1.0 micrometer.” However, neither Petitioner nor its expert identify any disclosure in Kobayashi of the dimensions of diameter of the circular trench contact. Pet., 35-36; Ex. 1003 ¶¶81. Instead, they note that Kobayashi discloses *other* measurements, and use the “apparent relative proportions of the MOSFET of Figure 5A” of Kobayashi to determine that “diameter of the circular trench contact is approximately the same as the width as the trench 6” and thus conclude “Kobayashi discloses that it is possible to obtain a circular trench contact width/diameter not greater than 0.5 μm .” *Id.*; Ex. 1003 ¶¶82.

However, this methodology is expressly foreclosed by Federal Circuit precedent, which holds that “arguments based on drawings not explicitly made to scale in issued patents are unavailing” as one should not “read[] precise proportions into patent drawings which do not expressly provide such proportions.” *Nystrom v. TREX Co., Inc.*, 424 F.3d 1136, 1149 (Fed. Cir. 2005); *see also Hockerson-Halberstadt, Inc. v. Avia Group International, Inc.*, 222 F.3d 951, 956 (Fed.Cir.2000) (rejecting argument that “hinges on an inference drawn from certain figures about the quantitative relationship between the respective widths of the

groove and fins” because “patent drawings do not define the precise proportions of the elements”). But that is exactly what Petitioner and its expert are doing—they point to no express statement in Kobayashi that its figures are to scale, nor do they point to any express disclosure in Kobayashi of the proportion between the width of the gate trench and the diameter of the trench contact. Indeed, there’s nothing to even indicate that Kobayashi’s cross-sections depict embodiments with circular (as opposed to square) contacts. Ex. 2021 ¶ 118; Ex. 1005. Thus, Petitioner’s anticipation theory for claim 5 is without merit.

B. Ground 2: Kobayashi in view of Kikkawa Fails to Render the Challenged Claims Unpatentable

1. Lack of Motivation to Combine

(a) Kikkawa Is Not Analogous Art

For a reference to be properly used in an obviousness combination, the reference must be analogous art to the claimed invention. *In re Bigio*, 381 F.3d 1320, 1325 (Fed. Cir. 2004). A reference is analogous art to the claimed invention if: (1) the reference is from the same field of endeavor as the claimed invention (even if it addresses a different problem); or (2) the reference is reasonably pertinent to the problem faced by the inventor (even if it is not in the same field of endeavor as the claimed invention). *Id.*

As to the field of endeavor, the ’409 Patent is directed to trenched power MOSFET. ’409 Patent, Title, Abstract, cl. 1 (reciting a “trenched power

semiconductor device”), Figs. 1-3 (depicting MOSFET devices of prior art and the invention); Ex. 2021 ¶119. Indeed, its “Field of Invention” section states that “[t]his invention relates generally to the cell structure, device configuration and fabrication process of power semiconductor devices.” ’409 Patent, 1:7-9. By contrast, the Kikkawa reference is directed to improved conductors (components for connecting different metal interconnect layers for DRAM). Ex. 2021 ¶119; Ex. 1007, 1 (Abstract) (“A new interconnection structure using a ... multilayer conductor ... as a quarter-micrometer interconnection candidate for 256-Mb DRAM.”), 7 (conclusion).

DRAM and Power MOSFETs, although both transistors, are very different types of semiconductor devices with different properties and pertinent design considerations. Ex. 2021 ¶119. Petitioner’s argument is essentially that the entire field of semiconductor design is a single field of endeavor. Pet., 41-42. But, a POSITA would not understand the field of endeavor to be so broad. Ex. 2021 ¶119. Indeed, the Federal Circuit has warned against excessively broad identifications of the field of endeavor. *Wang Laboratories, Inc. v. Toshiba Corp.*, 993 F.2d 858, 864 (Fed. Cir. 1993) (“art is not in the same field of endeavor as the claimed subject matter merely because it relates to memories”).

Similarly, examining the structure and function of Kikkawa versus the ’409 Patent further confirms they are in different fields of endeavor. Kikkawa is focused

on improving the structure of a *conductor*, which is a structure for connecting different metal interconnection layers within a DRAM. Ex. 2021 ¶122; Ex. 1007, 3-4. By contrast, the structure that Petitioner suggests is analogous in the '409 Patent—the trenched source contact plug—is used to form a connection with the underlying semiconductor cell. Ex. 2021 ¶¶120, 122; *compare* Ex. 1007, 7, Fig. 11 (b) (illustrating Kikkawa's multi-layer strip on top of an insulating SiO₂ layer) *with* '409 Patent, Fig. 3A (illustrating element 220 penetrating into n⁺ doped source layer and p-doped body).

Petitioner argues that Kikkawa is pertinent to a problem solved by claims 2 and 6 of the '409 Patent, arguing that the claimed titanium layer is “for reducing a contact resistance between said contact metal plug and said source metal.” Pet., 42; Ex. 1003 ¶99. However, Kikkawa is not directed to reducing *contact resistance*, it is directed to a multi-layer configuration of a conductor (having multiple titanium and aluminum layers) to reduce *stress migration and electro migration*. Ex. 1007, 3 (investigating “a new layered conductor structure is investigated for quarter-micrometer interconnections”).

Indeed, Petitioner and its expert admit that Kikkawa is directed to improving stress-migration and electro-migration ruggedness. Pet., 42. However, they argue that reducing electro-migration and stress-migration would ultimately, if the device is left on for an indeterminate period of time, result in a device with reduced contact

resistance compared to a similar device suffering from electro-migration and stress-migration. Ex. 1003 ¶85. But the capability of resisting electro-migration and stress-migration is distinct from *contact resistance*, which refers to the actual electrical resistance of the contact. Ex. 2021 ¶121. Moreover, in these apparatus claims, “reduc[ed] contact resistance” is not measured by what might occur over an unspecified period of time if the device is used—contact resistance is a property that can be measured from the contribution of the contact to resistance, whether the device is on or off. *Id.* Thus, Kikkawa is not reasonably pertinent to the problem of contact resistance—it is addressed to a distinctly different problem (electro-migration / stress-migration). Accordingly, Kikkawa is not analogous art, and Petitioner’s obviousness theory fails.

(b) Petitioner Fails to Identify an Adequate Reason to Combine Kobayashi and Kikkawa in the manner claimed.

As to the alleged benefits of combining Kobayashi and Kikkawa, Petitioner argues that “adding a titanium (Ti) or titanium nitride (TiN) layer to the bottom of Kobayashi’s source metal layer would improve the reliability of the metal layer through the reduction of stress-induced electro-migration.” Pet., 43.

However, this argument has a number of flaws. Neither Petitioner nor its expert articulates any reason to believe that Kobayashi suffers from electro-migration or stress-migration that would benefit from combination to Kikkawa. Ex.

2021 ¶122; Pet., 43; Ex. 1003 ¶101. In particular, Kobayashi already has a Ti / TiN barrier metal between its aluminum source layer and its silicon layers. Ex. 1005, Fig. 5A (element 16), 6:61-64, 9:30-33. Neither Petitioner nor its expert articulate any reason why a titanium layer or titanium nitride layer between Kobayashi's aluminum source metal layer and its tungsten plug would reduce electro-migration or stress-migration, or that such a combination would be predictable. 37 C.F.R. § 42.65(a) (conclusory expert testimony "entitled to little or no weight").

In addition, Kikkawa does not state that simply having a single titanium layer (as Dr. Liu proposes in his combination) can reduce electro-migration and stress-migration. Ex. 2021 ¶122. Instead, as discussed, Kikkawa identifies a particular, multi-layer conductor having multiple titanium and aluminum layers as theoretically having reduced electro-migration and stress-migration. Ex. 1007, 3-4. Finally, Kikkawa provides no disclosure or suggestion for locating the titanium layer between a contact metal *plug* and a source metal of a MOSFET. As discussed, Kikkawa relates to a *conductor* (i.e., for connecting distinct metal interconnect layers) in DRAM, not a plug (i.e. for connecting a metal layer to the active semiconductor material) in a MOSFET.

2. Claim 2

Claim 2 depends from claim 1. '409 Patent, cl. 2. Petitioner's arguments in ground 2 for alleged obviousness of claim 2 are based on Petitioner's arguments in

ground 1 that Kobayashi anticipates claim 1, which fail as discussed above. Pet., 37. Petitioner offers no argument or evidence that Kikkawa cures any of the deficiencies of Kobayashi identified above with respect to claim 1. That is, because Petitioner has failed to demonstrate that Kobayashi discloses each limitation of claim 1, Petitioner’s obviousness arguments for claim 2 fail for the same reasons discussed above for claim 1 in ground 1. *See supra*, VI.A.1; Ex. 2021 ¶123.

Additionally, as discussed above in the lack of motivation to combine section for this ground, Petitioner fails to articulate any reason to combine Kobayashi and Kikkawa to have a “a contact resistance reduction metal layer composed of a titanium (Ti) layer disposed above a top surface said contact metal plug and below a bottom surface of said source metal for reducing a contact resistance between said contact metal plug and said source metal,” as recited by claim 2. *See supra*, VI.B.1. And, as discussed, Kikkawa’s multilayer titanium conductor does not reduce contact resistance—contact resistance is distinct from improved ability to resist electro-migration and stress-migration. Ex. 2021 ¶¶122, 124. And, Kikkawa does not disclose or suggest putting a titanium layer between a contact metal plug and a source metal layer. Rather, as discussed, Kikkawa is directed to a multi-layer conductor for connecting metal interconnection layers within DRAM—it does not disclose plugs that contact a semiconductor. Thus, neither Kikkawa nor Kobayashi disclose or suggest the limitation of claim 2.

3. Claim 6

- a) **Kobayashi Fails to Disclose element 6[a]: “said trenched gates surrounding said transistor cells as closed cells constituting substantially square-shaped cells with truncated corners”**

Notably, in ground 2 as to claim 6, Petitioner and its expert simply point to the same evidence and argument they present with respect to limitation 1[a] of ground 1, despite the fact that claim 6 recites “truncated corners” instead of “rounded corners.” Pet., 39; Ex. 1003 ¶89. Thus, Petitioner’s arguments fail for all the reasons discussed above regarding limitation 1[a] in ground 1 apply equally here. *See supra* VI.A.1.a; Ex. 2021 ¶126. Indeed, Petitioner’s arguments for “truncated corners” are even weaker.

As a threshold issue, the side view “rounding” discussed in Kobayashi at 7:57-8:4 and depicted in Fig. 6C have no applicability to the “truncated corners.” Pet., 39; Ex. 2021 ¶127. In particular, as discussed above, neither “rounded corners” nor the “truncated corners” limitations should be construed to involve any process steps—they should be construed based on the actual appearance in the finished apparatus (i.e. rounded corners being those curved like an oval or circle, whereas truncated corners having the appearance of being cut off). Thus, Kobayashi’s description and depiction of the trench corner bottoms and openings as *rounded* fails to demonstrate corners which are *truncated*, and neither Petitioner nor its expert presents any testimony to the contrary. In addition, as discussed, both the “rounded

corners” of claim 1 and the “truncated corners” of claim 6 are those of the *square*-shaped cell—which are only visible from the top view—not merely the corners of the gate trench visible in the side view.

Additionally, neither the squares of Kobayashi’s Figure 3A, nor the hexagons of Kobayashi’s Figure 4A, satisfy this limitation as properly construed. Pet., 26. As to the squares of Kobayashi’s Figure 3A, they are plainly not truncated or cut off, but rather have the full, normal ninety-degree angled corners of a conventional square. This is plainly incongruous with the “truncated corners” as used in the ’409 Patent, as illustrated in Figure 2:

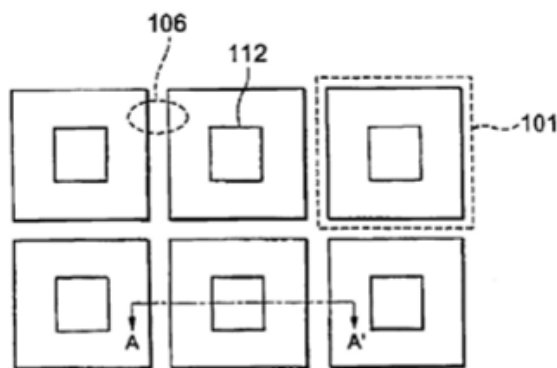


FIG.3A

Ex. 1005, Fig. 3A

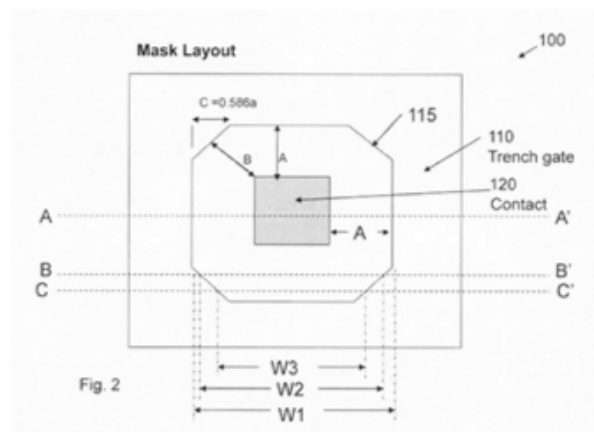


Fig. 2

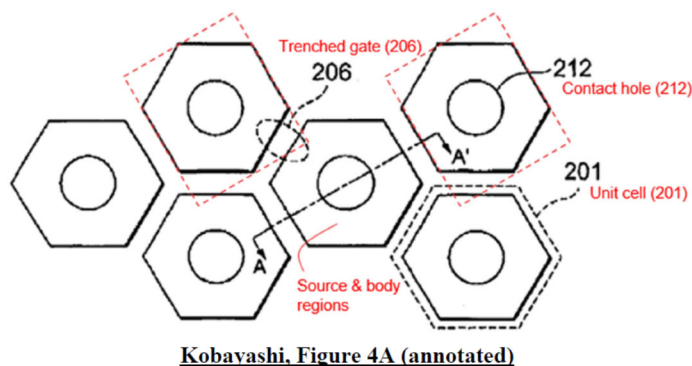
'409 Patent, Fig. 2

Neither Petitioner nor its expert present any argument to the contrary.

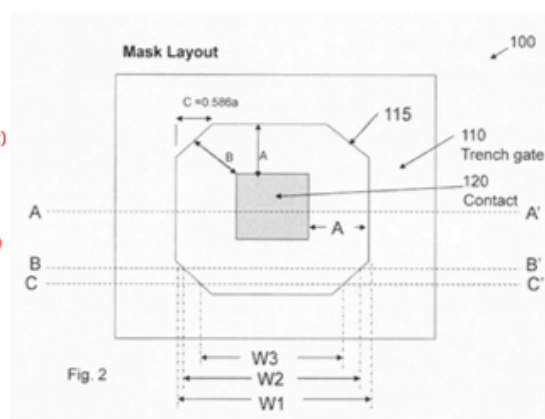
As to the hexagons of Kobayashi’s Figure 4A, as discussed above, hexagons are not substantially square shaped. *See supra* VI.A.1.a. Indeed, the only “evidence”

that Petitioner or its expert presents in support of such an argument is a diagram showing that squares can be drawn around the hexagons of Kobayashi's Figure 4A. Pet., 26; Ex. 1003 ¶68. But, neither Petitioner nor its expert provides any reasoned explanation why such hexagons are "*substantially square-shaped* cells with truncated corners." *Id.* As noted, hexagon-shaped cells and square-shaped cells are distinct categories of cell topologies in MOSFETs. Ex. 2021 ¶128. Indeed, Kobayashi itself identifies squares and hexagons as alternative cell layouts. Ex. 1005, 6:25-30. Moreover, Kobayashi's hexagons have six equal sides, while squares have four equal sides. *Id.* And, there is simply no factual basis to conclude that anything was truncated to form Kobayashi's hexagons—neither Petitioner nor its expert points to any such disclosure in Kobayashi. *Id.*; Pet., 26, 39; Ex. 1003 ¶68 (citing Ex. 1005, 6:3, Fig. 4A).

Furthermore, as illustrated in Figure 2 of the '409 Patent, a substantially square shaped cell with truncated corners still leaves something that is essentially square shaped, i.e. having four main sides which are longer than the truncated corners' sides. '409 Patent, Fig. 2. By contrast, in attempting to contort Kobayashi's hexagons into shapes derived from hypothetical squares, Petitioner cuts off far more than just four corners. Instead, as shown: they cut off so much from two of the hypothetical square's sides that all that is left are mere points, and the resulting shape has six equal sides.



Kobayashi, Figure 4A (annotated)



'409 Patent, Fig. 2 (cropped)

Pet., 26 (annotating Ex. 1005, Fig. 4A)

Petitioner offers no argument or evidence that Kikkawa cures any of the deficiencies of Kobayashi identified above with respect to claim 1. Instead, Petitioner solely relies on Kobayashi's disclosures for this limitation. Pet., 39; Ex. 1003 ¶89. Nor does petitioner offer any theory that it would be obvious to modify Kobayashi to meet this limitation. Pet., 39, 41, 47-48. Thus, Petitioner has not demonstrated that claim 6 is obvious.

b) Kobayashi and Kikkawa Fail to Disclose or Suggest element 6[g] "source metal layer composed of Ti/AlCu or Ti/AlSiCu alloys"

As discussed, above regarding lack of motivation and claim 2, (*supra* VI.B.1, VI.B.2), Petitioner fails to show that Kikkawa discloses or suggests the specific titanium structures of claim 6, or that a POSTIA would be motivated to combine Kobayashi and Kikkawa in the manner claimed. Ex. 2021 ¶129. Kikkawa does not disclose or suggest a titanium layer as part of a source metal above a metal plug.

Kikkawa is directed to a multi-layer conductor for connecting metal interconnection layers within DRAM—it does not disclose plugs that contact a semiconductor. Thus, neither Kikkawa nor Kobayashi disclose or suggest the limitation of claim 2.

4. Ground 2 Fails for Each Challenged Claim Because Petitioner Has Not Carried its Burden to Show that Kikkawa Was a Printed Publication Before the Priority Date

Petitioner contends that the Kikkawa reference is a printed publication under 35 USC § 102(b), i.e. that it was published more than one year the '409 Patent claims priority to a December 4, 2006 filing. Petitioner therefore has the burden of showing that the Kikkawa article was publicly available before December 4, 2005. *Hulu, LLC v. Sound View Innovations, LLC*, IPR2018-01039, Paper 29, 16 (PTAB Dec. 20, 2019) (precedential). Petitioner fails to present adequate evidence to carry that burden.

Petitioner relies upon the testimony of an expert witness on library sciences, Dr. Sylvia Hall-Ellis, to attempt to show that the issue of the IEEE journal containing Kikkawa was publicly available prior to the December 4, 2005 date for § 102(b). Notably, Dr. Hall-Ellis was not involved in the writing or publication of the Kikkawa article, nor was she personally involved in managing any of the systems which recorded the purported publication of Kikkawa or its deposit in any library. Ex. 2023, 32:13-21; 35:7-36:5. Rather, Dr. Hall-Ellis primarily relies on her

contemporary access, concurrent with her work on this declaration, of publicly accessible websites and internet databases. Ex. 1008 ¶44.

First, Dr. Ellis-Ellis relies upon electronic online database records, including those from IEEE Xplore, the Library of Congress and the Linda Hall Library of Science, Engineering & Technology that purport to show the date on which *IEEE Transactions on Electron Devices* began publication (i.e., the date of the first issue of the first volume). Ex. 1008 ¶¶45-49 (citing Exs. 1014-1017). However, Dr. Hall-Ellis has no personal knowledge that any of those records were made at or near the time by, or from information transmitted by, someone with knowledge, or that they have been accurately maintained. *Id.*; Ex. 2023, 32:13-21, 45:20-46:9. Moreover, none of those records have any specific relationship to Kikkawa—they do not show that Kikkawa itself was actually published prior to the priority date. *Id.*, 32:13-21; Ex. 1017. Showing that the journal began publication in 1974 does not show that a specific issue with a specific article Kikkawa was actually published before December 4, 2005.

Second, Dr. Hall-Ellis relies upon an apparent stamp on the cover of the photocopied version of the journal and article which appears to read “Linda Hall Library” and “Jan 26, 1993” according to the expert (in Ex. 2007, the stamp is faint and illegible). Ex. 1008 ¶46; Ex. 2023, 37:25-38:15. The expert relies upon general practice in libraries regarding stamping, and her claimed knowledge of stamping

practices at the Linda Hall Library of Science, Engineering & Technology where the photocopied article appears to have originated. *Id.*, 33:8-35:6 However, Dr. Hall-Ellis conceded that she had not recently spoken with anyone at the library regarding their stamping practices, had not spoken to anyone at the library since she became involved in this case, and does not know who affixed this stamp. Ex. 2023, 35:7-36:7. Thus, Dr. Hall-Ellis has no personal knowledge that the stamp on the Kikkawa is accurate, or the reliability of the practices at the Linda Hall Library at the relevant time period to infer that Kikkawa was accurately stamped.

In short, although Petitioner has channeled arguments regarding public availability through an expert, that expert has no personal knowledge regarding the relevant facts, and instead is attempting to relay hearsay information—the public records and an apparent stamp on the journal. Such hearsay is not sufficient to carry Petitioner’s burden of public availability prior to the priority date. *See ServiceNow Inc., v. Hewlett-Packard Co.*, IPR2015-00716, Paper No. 13, 8, 15-17 (P.T.A.B. Aug. 26, 2015).

C. Ground 3: Kobayashi in view of alleged knowledge of a POSITA Fails to Render the Challenged Claims Unpatentable

1. Lack of Motivation to Modify

Claim 5 depends from claim 1 and further recites “a diameter of a top surface of said circular trench contact is smaller than 1.0 micrometer.” In this ground, Petitioner relies on the Kobayashi reference alone to render this limitation obvious.

Pet., 49-51. As discussed above in connection with ground 1, claim 1, Kobayashi contains no such disclosure. *Supra* VI.A.3; Ex. 2021 ¶¶118, 130. Indeed, Petitioner repeats its improper argument attempting to discern measurements from the relative proportions of Kobayashi's figures. As discussed, such arguments are legally improper. *Nystrom*, 424 F.3d at 1149; *Hockerson-Halberstadt*, 222 F.3d at 956.

The only additional arguments presents in this single-reference obviousness grounds are appeals to vague, purported "design considerations." Pet., 50. However, the Federal Circuit has warned such arguments must be closely scrutinized. *Arendi v. Apple*, 832 F.3d 1355, 1363 (Fed. Cir. 2016) (where "'common sense' is used to supply a missing limitation, as distinct from a motivation to combine ... search for a reasoned basis for resort to common sense must be searching" and will typically "fill in a missing limitation only when 'the limitation in question was unusually simple and the technology particularly straightforward'"); *DSS Technology Management, Inc. v. Apple Inc.*, 885 F.3d 1367, 1374-76 (Fed. Cir. 2018) (applying same standard to obviousness argument based on "ordinary creativity" as a gap-filler).

Here, Petitioner's only evidence to support such gap-filling are a few conclusory statements by its expert, which contain no citations to other evidence, to argue that "the width of the source contact trench would be close to the minimum feasible width (diameter) that can be possibly obtained by the given technology

capability at the time of invention (which is no greater than 0.5 μm as stated by Kobayashi).” Ex. 1003 ¶¶111-114. In particular, Dr. Liu argues that a wider width of the source contact trench: (1) “would lead to wider total width of the unit cell ... making the device less economical to manufacture” (Ex. 1003 ¶112); (2) “would dictate that the P+ base layer will be closer to its adjacent trench gate on both sides, and would lead to an increase of threshold voltage;” (*Id.* ¶113); and (3) would increase tungsten deposition time. (*Id.* ¶114). Because these statements are unsupported, they should be disregarded. 37 CFR § 42.65(a).

As Dr. Neikirk explains, the first and third of these reasons are entirely generic motivations untethered to the specific disclosures of Kobayashi—there is always a motivation to speed up the fabrication process or shrink feature sizes of semiconductors. Ex. 2021 ¶131. But those generic arguments fail to articulate any reason why it would be obvious to use trench contacts with a diameter smaller than the specific measurement of 1.0 micrometers, as claimed. *Id.* Indeed, Dr. Liu presents no analysis explaining how the theoretical differences in cell size or fabrication speed would actually be meaningful. As to Dr. Liu’s second argument, Kobayashi already addresses the issue of the P+ base layer potentially increasing threshold voltage. *Id.* (citing Ex. 1005, 5:44-49). Thus, that is not a reason for using circular trench contact smaller than 1.0 micrometer in diameter. Ex. 2021 ¶131.

And, again, Dr. Liu presents no analysis explaining how the increase in threshold voltage would be meaningful.

Furthermore, Petitioner presents no evidence that modifying Kobayashi in the manner claimed would be *predictable*. Indeed, Kobayashi's gate dimensions do not directly translate to its contact trench dimensions—the gates are filled with silicon, rather than metal. Ex. 1005, 6:53-57. Moreover, Dr. Liu fails to discuss any potential downsides of decreasing source contact diameter. For example, it would be more difficult to filling in Kobayashi's metal plugs if the diameters are reduced. Ex. 2021 ¶131. Dr. Liu also ignores that narrower trenched source contacts would have reduced current carrying ability. Ex. 2021 ¶131.

In short, Petitioner and its expert present inadequate reasoning in an attempt to gap-fill a limitation not disclosed by the cited references. Because the technology here is not straightforward, and the limitation in question is not unusually simple, the conclusory reasons provided fall far short of the Federal Circuit's "searching" standard for such gap-filling.

2. Claim 5

Claim 5 depends from claim 1. '409 Patent, cl. 5. Petitioner's arguments in ground 3 for alleged obviousness of claim 5 are based on Petitioner's arguments in ground 1 that Kobayashi anticipates claim 1, which fail as discussed above. Pet., 49. Petitioner offers no argument or evidence that the knowledge of a POSITA cures

any of the deficiencies of Kobayashi identified above with respect to claim 1. That is, because Petitioner has failed to demonstrate that Kobayashi discloses each limitation of claim 1, Petitioner's obviousness arguments for claim 5 in ground 3 fail for the same reasons discussed above for claim 1 in ground 1. *See supra*, VI.A.1.a. Moreover, as discussed, Kobayashi does not disclose or suggest the added limitation of claim 5, and Petitioner does not provide an adequate motivation to modify Kobayashi in the manner claimed. Ex. 2021 ¶¶132-133.

D. Ground 4: Kobayashi in view of Hshieh Fails to Render the Challenged Claims Unpatentable

1. Lack of Motivation to Combine

As discussed further below, Petitioner's motivation to combine Kobayashi and Hshieh fails because it: (1) conflates different types of rounding; (2) contradicts Hshieh's basic objectives; (3) disregards differences in the cited art, instead using hindsight to arbitrarily cherry-pick limitations; and (4) ignores that Hshieh's teachings regarding the "three dimensional diffusion" phenomenon are inapplicable to Kobayashi.

(a) Petitioner improperly conflates different types of rounding to argue that rounded or truncated corners were "known"

In Petitioner's motivation to combine analysis, Petitioner repeatedly conflates the side view rounding of trench gate bottoms and openings (such as in Kobayashi and Kim) with the top-view rounding of cell corners (such as in Hshieh). Pet., 58-

62. By doing so, Petitioner then concludes that: (1) “methods of truncating, blunting, and rounding [] corners, are all known, conventional, familiar elements;” (Pet., 59) (2) rounded or blunted corners are “known methods for addressing problems with sharp corners in closed cells” (*id.*); and (3) rounding corners “applies a known technique” (Pet., 60).

However, these arguments improperly conflate different types of rounding that occur in different places for different purposes. Ex. 2021 ¶¶136, 113, 115. As discussed above in connection with Petitioner’s anticipation ground for claim 1 over Kobayashi, Kobayashi does not discuss rounding of *cell* corners (i.e. rounding visible from the top view), but rather discusses rounding of the *trench bottom* and opening corners (i.e. rounding which is only visible from a side view cross-section); Ex. 2021 ¶136, 104, 112-115. Similarly, the Kim reference is focused on side-view rounding of gate trench bottom and openings, not the rounding of corners of a closed cell. Ex. 1012, 1, Fig; Ex. 2021 ¶136-137. The side view rounding of gate trench bottoms and openings relates to gate “leakage,” and in particular, the problem of current conduction between gate and drain that can occur via tunneling due to thinning of the gate oxide at such corners. Ex. 2021 ¶137; Ex. 1011, 1:34-40; Ex. 1012, 1; *see also* Ex. 2006, 1:34-53.

By contrast, Hsieh uses rounding in a different way, and at a different place (top view rounding) and in a manner unrelated to the type and purpose of rounding

in Kim and Kobayashi. In particular, as discussed further below, Hshieh is concerned with the three-dimensional diffusion phenomenon, which causes short channels at cell corners of double diffused MOSFETs, particularly for Hshieh's non-orthogonal parallelograms. Ex. 2021 ¶138; Ex. 1006, 2:19-34. As discussed, claim 1 does not require that there simply be "rounding" *anywhere* on the gate trenches, it specifically recites "substantially square-shaped cells with rounded corners," i.e. cells having rounded corners from the top view. *See supra* V.A. Thus, Petitioner and its expert fail to provide any evidence that *top view* rounding of cell corners was well-known or conventional.

Additionally, the fact that particular technique is "known" is not sufficient for a motivation to combine. *Virtek Vision Int'l ULC v. Assembly Guidance Sys.*, 97 F.4th 882, 888 (Fed. Cir. 2024) ("It does not suffice to simply be known. A reason for combining must exist."). Examining Petitioners actual *reasons* for combining Hshieh with Kobayashi—i.e. benefits—only two appear in the Petition. First, the Petition mentions twice that the Kobayashi-Hshieh combination results in the benefit of "electro-migration and contact resistance." Pet., 61, 62. However, that appears to be a typo, as Petitioner's expert identifies that as a benefit of Kikkawa, not Hshieh. Ex. 1003 ¶¶85, 99, 103-104, 108, 146. Petitioner presents no explanation why combining Hshieh with Kobayashi would result in electro-migration and contact resistance.

The only remaining obviousness motivation that the Petition identifies is that Hshieh’s purported express disclosures of the benefit of rounding cell corners. Ex. 1003 ¶137. In particular, Petitioner argues that Hshieh “discloses the problems of vulnerable punch-through weak points in the corners of square cells, [which is] due to undesirable higher peak electric field being reached at the corners.” Pet. 57–58. They cite to Hshieh’s statement that “[i]n order to prevent the corner vulnerability where punch through weak points may be formed at the sharp corners due to a three-dimension diffusion effect . . . , the sharp corners [of the cells] can be either be blunted or rounded.” Ex. 1006, 5:3–8.

However reliance on Hshieh’s disclosures regarding sharp corners as a motivation fails for two major reasons, discussed further below. First, Hshieh expressly teaches against square-shaped cells. *Infra* VI.D.1.b. Second, the “corner vulnerability” discussed in Hshieh—short channel length in corners resulting from the three-dimensional diffusion phenomenon—is inapplicable to the structure of Kobayashi’s MOSFET. *Infra* VI.D.1.d

**(b) Petitioner’s Proposed Combination Contradicts
Hshieh’s Basic Objective**

As Patent Owner explained in its preliminary response, Hshieh teaches away from “substantially square-shaped cells with rounded corners” because Hshieh is directed to increasing the packing density of the cell topology of power transistors by using “*non-orthogonal parallelograms*.” Ex. 1006, Abstract (emphasis added),

2:64-3:55, 4:32-5:2, Figs. 5A-5B, cls. 1, 8, 12, 21, 26, 30. By definition, non-orthogonal parallelograms do not have right corners, and thus are not square shaped. Ex. 2021 ¶142. Indeed, Hshieh specifically identifies square cell configurations as having disadvantageous packing densities: “[t]he packing density of the transistor cell is improved with the parallelogram cell occupies less areas than *the regular square cell* having the same total channel width.” Ex. 1006, Abstract (emphasis added); *see also id.*, 1:14-23 (identifying power MOSFETs having “cellular structure” with “square” topologies as having increased “JFET resistance” and “on-resistance,” particularly as “cell size is reduced.”), Figs. 2C.

In contrast to squares, Hshieh touts its “non-orthogonal parallelogram” cell layout as providing “*packing density [that] is increased* with the same total channel width formed in a smaller cell area *when compared to that of square cells* as [] commonly used in the prior art such that the cell size can be further reduced without sacrificing the total channel width.” *Id.*, 2:64-3:5 (emphasis added). Moreover, Hshieh discloses that its use of rounding is intended to address the problem of the “sharp corners” created by using non-orthogonal parallelograms: “the punch through vulnerability at the *weak points in these sharper corners of the non-orthogonal parallelogram cells* may be eliminated” Ex. 1006, 3:6-14 (emphasis added); *DePuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.*, 567 F.3d 1314, 1326 (Fed. Cir. 2009) (“An inference of nonobviousness is especially strong where the prior art’s teachings

undermine the very reason being proffered as to why a person of ordinary skill would have combined the known elements.”).

In its Institution Decision, the Board expressed skepticism whether these teachings rose to the level of “teaching away,” stating that these disclosures merely provide that “non-orthogonal cells are preferable over square cells,” and thus does not rise to the level of “criticiz[ing], discredit[ing], or otherwise discourag[ing]” the combination. Paper 9, 25. Patent Owner respectfully disagrees with the Board. Hshieh’s statements clearly state that square-shaped cell topologies are disadvantageous, which would naturally steer a POSA toward non-orthogonal parallelograms. *See, e.g., In re Gurley*, 27 F.3d 551, 553 (Fed. Cir. 1994) (“A reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the applicant [t]he degree of teaching away will of course depend on the particular facts”); *Chemours Company Fc, LLC v. Daikin Industries*, 4 F.4th 1370, 1375-77 (Fed. Cir. 2021) (finding teaching away when prior art noted relative disadvantages of known methods).

However, in any event, Hshieh’s teachings regarding non-orthogonal parallelograms are relevant and weigh against obviousness, even if they do not rise to the level of “teaching away.” Indeed, “[t]he absence of a formal teaching away

in one reference does not automatically establish a motivation to combine it with another reference in the same field.” *Rembrandt Wireless Tech., LP v. Samsung Elecs. Co. Ltd.*, 853 F.3d 1370, 1379-80 (Fed. Cir. 2017). “[E]ven if [a reference] does not teach away, its statements ... are relevant to a finding regarding whether a skilled artisan would be motivated to combine....” *Apple Inc. v. Samsung Elecs. Co., Ltd.*, 839 F.3d 1034, 1051 n.15 (Fed. Cir. 2016) (en banc); *Arctic Cat v. Bombardier Recreational Products*, 876 F.3d 1350, 1360 (Fed. Cir. 2017) (“As our precedent reflects, prior art need not explicitly ‘teach away’ to be relevant to the obviousness determination”); *WBIP, LLC v. Kohler Co.*, 829 F.3d 1317, 1337 (Fed. Cir. 2016) (“Whether a skilled artisan would be motivated to make a combination includes whether he would select particular references in order to combine their elements.”).

Hshieh’s express statements of the relative disadvantages of square cell topologies are particularly relevant given, as discussed above, Petitioner’s obviousness theory relies on other statements in Hshieh as an express motivation to combine Hsieh with Kobayashi to form the limitation “substantially **square**-shaped cells with rounded corners”. In particular, the Federal Circuit has repeatedly found that a combination that would defeat the basic objective of one of the references or render it inoperable for its intended purpose are unlikely. *In re Ratti*, 270 F.2d 810, 813 (CCPA 1959); *In re Gordon*, 733 F.2d 900, 902 (Fed. Cir. 1984); *Trivascular, Inc. v. Samuels*, 812 F.3d 1056, 1068 (Fed. Cir. 2016) (finding non-obviousness

when “proposed substitution would destroy the basic objective of” aspect of one of prior art references”). In Hshieh, non-orthogonal parallelograms are not merely a preferred alternative—the improved packing density of non-orthogonal parallelograms are the entire purpose of Hshieh’s invention. Ex. 1006, Title, Abstract, cls. 1, 8, 12, 21, 26, 30. The basic objective of Hshieh is not satisfied by a combination using square-shaped cells.

(c) Petitioner Disregards the Differences In Structure and Purpose Between the Cited Art and the Claimed Invention, and Instead Engage in Arbitrary Cherry-Picking and Hindsight

It is fundamental to an obviousness analysis to examine the scope and content of the prior art and the differences between the claimed invention and the prior art. *Graham v. John Deere Co.*, 383 U.S. 1, 17-18 (1966). As discussed, the ’409 Patent is directed the prior art’s problem of non-uniform distances between trench gates and the source trench contact. ’409 Patent, 1:15-57, 2:3-7. Its solution to that problem is a combination of features for an improved cell layout—features which are recited in the claims themselves: substantially square-shaped cells with rounded (or truncated) corners and a circular trench contact. ’409 Patent, Fig. 3, 1:66-2:9, cls. 1, 6.

By contrast, Hshieh’s structure is fundamentally different. Ex. 2021 ¶145. And all of Hshieh’s embodiments have parallelogram cells with parallelogram shaped contact openings. Ex. 1006, Figs. 4A, 5A-8B, 10A. Nearly all of Hshieh’s

disclosed embodiments lack trench gates. Ex. 1006, Figs. 6A-8B. Indeed, none of the depicted or disclosed embodiments with rounded corners in Hshieh's specification have trench gates. *Compare* Ex. 1006, Figs. 6A-8B *with id.*; Figs. 10A, 10B (not depicting Figs. 10A and 10B as having rounded or blunted corners); *see also id.*, 3:58-4:28 (only describing Figs. 10A and 10B as having trenches). Moreover, all of Hshieh's embodiments entirely lack trenched source contacts. Ex. 1006, Figs. 6A-8B, 10B. Thus, not surprisingly, Hshieh's "rounding" is not concerned with trenched source contacts. Rather, Hshieh uses rounding and blunting to address the effect of the "three dimension diffusion effect" at the two sharper corners of Hshieh's non-orthogonal parallelograms in double diffused MOSFETs. *Id.*, 5:3-17. Hshieh does not disclose or suggest that rounded or blunted corners are useful for a square topology. Ex. 2021 ¶145.

Petitioner's motivation to combine analysis ignores these differences. Instead, Petitioner's combination reflects an unexplained and arbitrary selection of features from different embodiments of Kobayashi and Hshieh based solely on hindsight bias. Ex. 2021 ¶151. Without explanation, Petitioner selects Kobayashi's square-gird cell topology for the combination, rather than Kobayashi's hexagon or elongated cell topologies or Hshieh's non-orthogonal parallelogram topology. Pet., 52; Ex. 1005, 6:26-32, Figs. 3A, 3B, 4A, 4B; Ex. 1006, Figs. 5A-8B, 10A. Similarly, without explanation, Petitioner selects Kobayashi's circular contact shape, rather

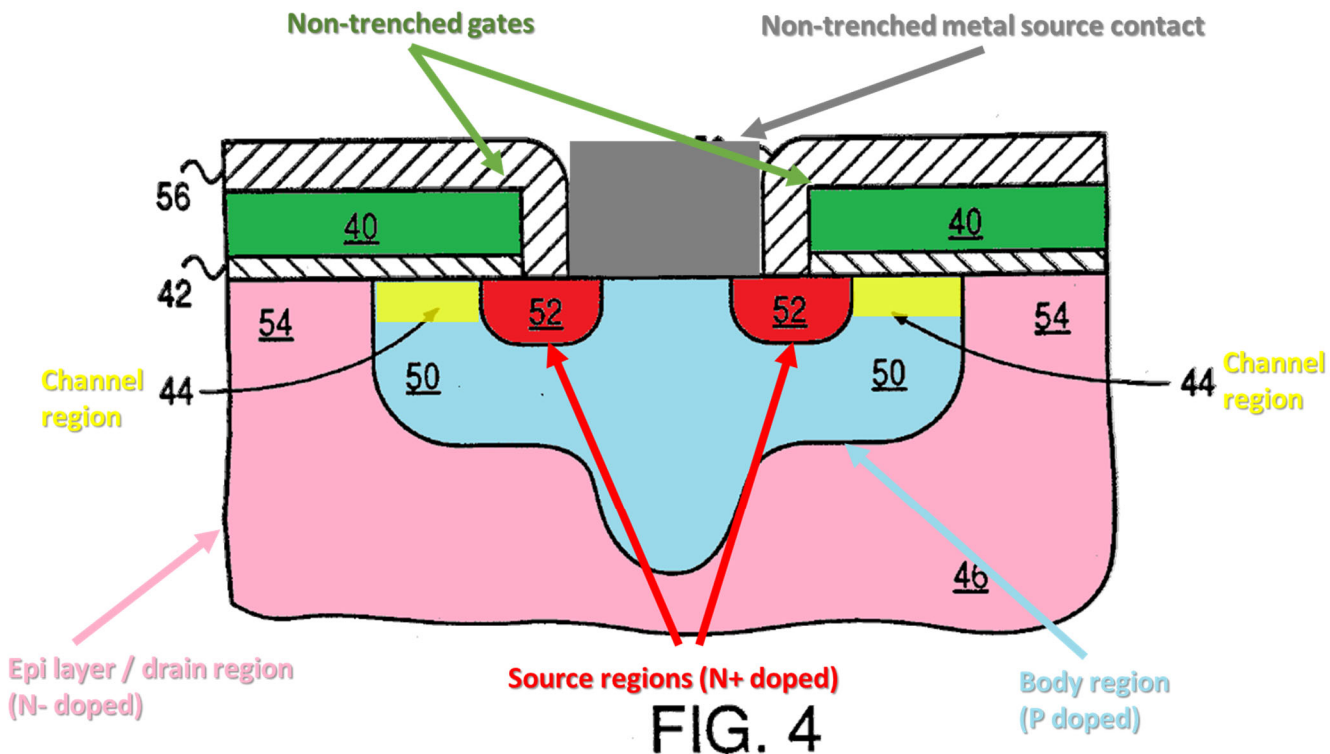
than its square, hexagonal, octagonal shapes or Hshieh's non-orthogonal parallelogram source contact openings. Pet., 52-53; Ex. 1005, 6:35-39; Ex. 1006, Figs. 5A-8B, 10A. Additionally, without explanation, Petitioner selects to use Kobayashi's trench-gate trench-source MOSFET structure instead of Hshieh's vertical-draining double diffused MOSFETs or trench gate MOSFETs without trenched source contacts. Pet., 52-54. And, without explanation, Petitioner selects to use Hshieh's embodiments with all corners rounded, instead of Hshieh's embodiments with some or all corners unrounded. Pet., 53-54; Ex. 1006, Figs. 5A-10B. The result of this arbitrary selection among a number of choices happens to be a cell structure that solves the problem of non-uniform source contact to gate trench distances in the same way as the '409 Patent—despite the fact that Petitioner makes no showing that such problem was even known in the prior art. This approach is clearly contrary to Federal Circuit precedent. *Cheese Sys., Inc. v. Tetra Park Cheese and Powder Sys., Inc.*, 725 F.3d 1341, 1352 (Fed. Cir. 2013) (prohibiting the “the hindsight combination of components selectively culled from the prior art to fit the parameters of the patented invention.”).

(d) Hshieh's teachings regarding benefits of “rounded” or “blunted” corners are inapplicable to Kobayashi

Although the Board found Hshieh's express teachings reaching the three-dimensional diffusion phenomenon persuasive in its Intuition Decision (Paper 9, 26), Petitioner wholly fails to present any evidence or argument that the three-

dimensional diffusion phenomenon is actually applicable to Kobayashi's MOSFET. Pet. at 59; Ex. 1003 ¶¶136-144. Indeed, as Dr. Neikirk explains, the three-dimensional diffusion problem identified by Hshieh is inapplicable to the structure of Kobayashi's MOSFET. Ex. 2021 ¶¶146-150.

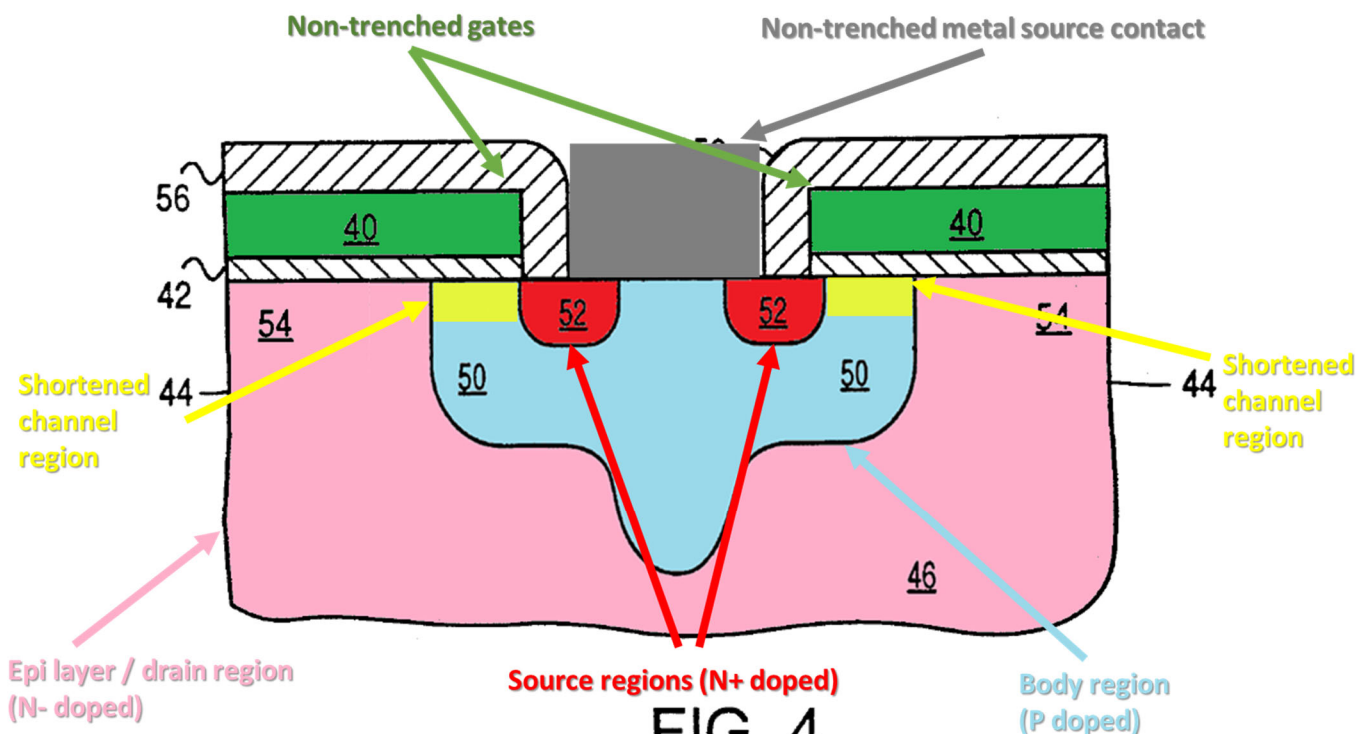
In particular, as Hshieh itself notes, the three-dimensional diffusion phenomena arises in vertical draining double diffused MOSFETs, not Kobayashi's trench-gate, trenched-source contact MOSFET. Ex. 1006 (Hshieh), 1:36-55, 2:19-35, Fig. 1. Similarly, the Yilmaz reference—which Hshieh specifically cites as explaining the three-dimensional diffusion phenomenon—reinforces that the problem is inapplicable to MOSFETs like Kobayashi. Rather, Yilmaz explains that the phenomenon is a problem with double diffused MOSFETs because implant N⁺ source wells into P-doped bodies, resulting in a channel that is largely *horizontal*. Ex. 2012, 3:42-4:11, Figs. 3-4; Ex. 2021 ¶147. Because P-type dopants have worse *horizontal* diffusion than N-type dopants—especially in corners—the result is that cell corners in double diffused MOSFETs can have excessively short channel length, which risks punch-through. *Id.* The following annotated and modified versions of Fig. 4 of Yilmaz approximately depict this. In a first example (Fig. 4 of Yilmaz with coloring), there is a sufficiently long horizontal channel:



Ex. 2012 (Yilmaz), Figure 4 (annotated with colors, text and arrows),
showing cell cross-section outside of corners with standard length channel

Ex. 2021 ¶147.

The next figure, which is a modified version of Yilmaz's Fig. 4, illustrates how the reduced horizontal diffusion of P-dopants in the corner results in shorter channel length in a double diffused MOSFET:



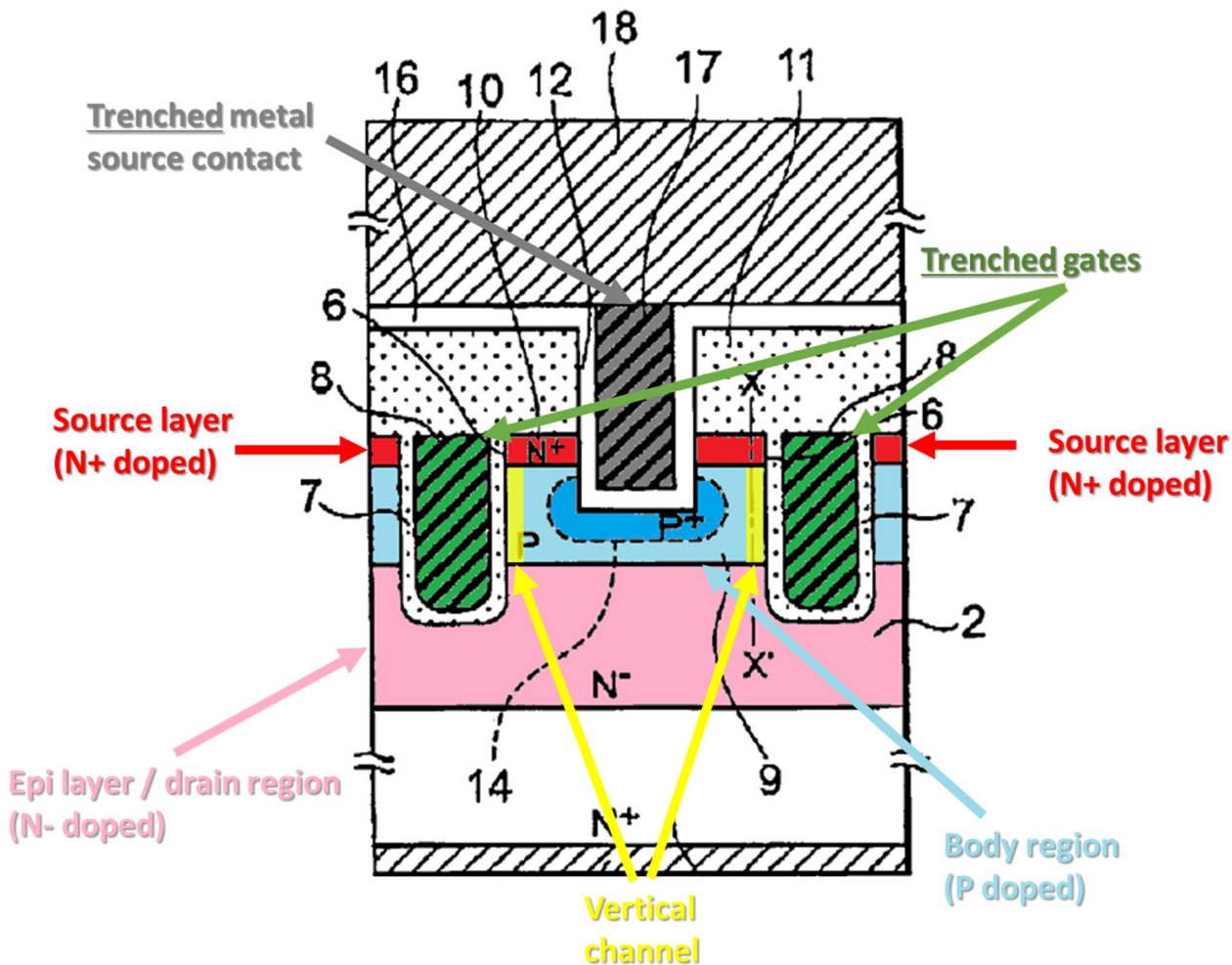
Version of Ex. 2012 (Yilmaz), Fig. 4 (horizontally compressed cell; and annotated), showing mock-up of cross-section at cell corners with shortened channel length

Ex. 2021 ¶147.

As shown, because of the reduced degree of diffusion of the p-type dopants that are used to create the p-doped body region at the corners, the result is a shortened channel length (yellow) in the second figure, compared to the unaltered version of Fig. 4 (which illustrates a the cross-section in the middle of the cell). Ex. 2012, Fig. 3 (showing line F.4), 2:16-18, Thus, Yilmaz—and Hshieh by citing Yilmaz—discloses that using blunted corners reduces the three-dimensional diffusion problem

in double diffused MOSFETs because the less-sharp corners allow the P-type dopants to diffuse further horizontally, preventing the excessively short channel lengths of these horizontal channels in the corners. Ex. 2012, 4:12-428; Ex. 1006, 2:19-34.

However, unlike Yilmaz and Hsieh, Kobayashi is a MOSFET with *trench*-gates and *trench*-source contacts. Ex. 1005, Abstract, Fig. 5A. Trench MOSFETs have a *vertical* channel, along the trenched gate. Ex. 1005, 7:1-10, Fig. 5A; Ex. 2024 at 157:21-158:12. As a result, the three-dimensional diffusion phenomenon (i.e. the differences in *horizontal* diffusion between P-type and N-type dopants) is irrelevant to the length of Kobayashi's *vertical* channel. Ex. 2021 ¶¶149-150. Moreover, as a result of Kobayashi's use of both source trenches and gate trenches, it has no horizontal/lateral boundaries between the source and body regions or the body and drain regions, and instead has only vertical/depth-wise boundaries. *Id.*; Ex. 2024 at 157:14-17. This is shown in the below annotated version of Fig. 5A of Kobayashi:



Ex. 1005, Figure 5A (cropped, annotated and colored)

As shown, Kobayashi's channel (yellow) is *vertical*. Moreover, the interfaces between the source layer (red) and body region (light blue), as well as between the body region (light blue) and the drain region (pink) are solely defined by the *vertical depth* of dopant diffusion of the implant used to create the source layer. Ex. 2021 ¶150. Indeed, Kobayashi body and source layers are created without any photoresist mask within the cell region, and thus there is nothing that could define horizontal boundaries between the source, body, or drain regions. *Id.*; Ex. 1005, 8:21-46, Fig.

7A. Because the length of Kobayashi’s vertical channel is determined by the vertical depth of implantation and diffusion of the source layer and body region, the three-dimensional diffusion phenomena—the differential rates of horizontal diffusion of P and N type dopants in corners—is simply not a problem for Kobayashi’s MOSFET. *Id.*

Indeed, at his deposition, Petitioner’s expert, Dr. Liu, did not dispute that Kobayashi would not have shorter channels in corners. Ex. 2024, 159:7-20. Moreover, Dr. Liu could not articulate a reason that the three dimensional diffusion phenomenon applies to Kobayashi—instead stating that there are “other effect[s]” contributing to punch-through. *Id.*, 158:13-159:6. But any such theories about other effects are not disclosed in the Petition, and thus are not appropriately a basis for a motivation to combine. Indeed, Dr. Liu could not identify anywhere in Hshieh as disclosing problems associated with corners other than the three dimensional diffusion. *Id.* at 168:21-170:11.

Because the three dimensional diffusion effect does not apply to Kobayashi, Hshieh expresses no motivation to round the corners of Kobayashi. Accordingly, Petitioners have identified no adequate motivation to combine Hshieh and Kobayashi in the manner claimed.

2. Claim 1

In ground 4, Petitioner and its expert argue that it would have been obvious to combine Kobayashi with Hshieh to achieve the structure of element 1[a] (“said trenched gates surrounding said transistor cells as closed cells constituting substantially square-shaped cells with rounded corners”). Pet., 51-54, 56-63. As discussed in ground 1, Kobayashi alone fails to disclose or render obvious “substantially square shaped cells with rounded corners.” *See supra* VI.A.1.a; Ex. 2021 ¶152.

Moreover, as discussed above regarding lack of motivation to combine (*supra* VI.D.1), neither Kobayashi nor Hshieh disclose or suggest “substantially square-shaped cells with rounded corners.” Ex. 2021 ¶153. In particular, as discussed, Petitioner’s argument that “rounding” was known and conventional improperly conflates Hshieh’s top view rounding with unrelated side view rounding. Moreover, as discussed, Hshieh’s disclosures—including those regarding rounded—are directed to non-orthogonal parallelograms, and Hshieh teaches away from square-shaped cells. And, Petitioner’s combination ignores the important differences in structure and purpose between Hshieh and the ’409 Patent’s claimed configuration, instead cherry picking separate embodiments from Kobayashi and Hshieh without explanation. And finally, Hshieh cannot provide an express combination to modify Kobayashi to use rounded corners because Hshieh’s three dimensional diffusion

phenomenon is inapplicable to Kobayashi (and Petitioner and its expert fail to even present any evidence or argument that it is).

3. Claims 3-5

Claims 3-5 depend from claim 1. '409 Patent, cls. 3-5. Petitioner's arguments in ground 4 for alleged obviousness of claims 3-5 are based on Petitioner's obviousness arguments in ground 4 for claim 1, which fail as discussed above. Pet., 55-56; *see supra* VI.D.1, VI.D.2. Thus, Petitioner has not demonstrated that claims 3-5 are obvious. Ex. 2021 ¶152-154.

4. Claim 5

(a) **Kobayashi Fails to Disclose claim 5: “a diameter of a top surface of said circular trench contact is smaller than 1.0 micrometer”**

In this ground, Petitioner's arguments for the limitation added in dependent claim 5 rely on its anticipation arguments for claim 5 based on Kobayashi in ground 1. Pet., 56. As discussed above in connection with ground 1, Petitioner's anticipation arguments fail. *Supra* VI.A.3. In this ground, Petitioner makes no argument that Hsieh cures any of the deficiencies discussed above in ground 1. Accordingly, Petitioner's arguments that claim 5 is rendered obvious by Kobayashi in view of Hsieh also fail. Ex. 2021 ¶154.

E. Ground 5: Kobayashi in view of Hshieh and Kikkawa Fails to Render the Challenged Claims Unpatentable

1. Lack of Motivation to Modify / Combine

The Petition fails to provide *any* reasoning for a motivation to combine Kobayashi, Hshieh and Kikkawa together. Pet., 63-67. This alone requires that ground 5 be rejected, as each distinct combination requires its own motivation to combine. 315 USC § 312 (a)(3) (grounds to be identified with particularity); 37 CFR § 42.6(a)(3) (prohibiting incorporation by reference of arguments from another document (i.e. an expert declaration) into the petition). Furthermore, to the extent that Petitioner were permitted to simply rely on their motivation to combine arguments for the separate Kobayashi-Hshieh and Kobayashi-Kikkawa combinations, those arguments fail for the same reasons discussed above. *See supra* VI.B.1, VI.D.1; Ex. 2021 ¶¶155-156.

2. Claim 2

Claim 2 depends from claim 1. '409 Patent, cl. 2. Petitioner's arguments in ground 5 for alleged obviousness of claim 2 are based on Petitioner's arguments that Kobayashi and Hshieh render obvious claim 1, which fail as discussed above in ground 4. Pet., 37. Petitioner offers no argument or evidence that Kikkawa cures any of the deficiencies of the Kobayashi-Hshieh combination discussed in connection with ground 4 with respect to claim 1. That is, because Petitioner has failed to demonstrate that Kobayashi-Hshieh renders obvious claim 1, Petitioner's

obviousness arguments for claim 2 fail for the same reasons. *See supra*, VI.D.1, VI.D.2; Ex. 2021 ¶157-158.

3. Claim 6

(a) **Petitioner Fails to Articulate a Sufficient Motivation to Combine Kobayashi and Hshieh in the Manner Claimed by Limitation 6[a]**

Petitioner's arguments in ground 5 for alleged obviousness of limitation 6[a] of claim 6 (which recites "truncated corners") are based on Petitioner's arguments that Kobayashi and Hshieh render obvious limitation 1[a] of claim 1 (which recites "rounded corners"), which fail as discussed above in ground 4. *Pet.*, 65-67. In particular, Petitioner offers no argument or evidence that Kikkawa cures any of the deficiencies of the Kobayashi-Hshieh combination discussed in connection with ground 4 with respect to claim 1. That is, because Petitioner has failed to demonstrate that Kobayashi-Hshieh renders obvious claim 1, Petitioner's obviousness arguments for claim 6 fail for the same reasons. *See supra*, VI.D.1, VI.D.2; Ex. 2021 ¶157-158.

In particular, the disclosures of Hshieh relating to "blunted" corners have the same problems as the disclosures of Hshieh relating to "rounded" corners. First, Petitioner improperly conflates side view rounding of trench bottoms/openings with top view truncation of corners. *See supra* VI.D.2, V.A, VI.A.1.a. Second, Hshieh expressly teaches away from using square shaped cells, and the combination would

violate Hshieh's basic objectives. *See supra* VI.D.1.b. Third, because Hshieh has a very different MOSFET structure, the problems addressed by Hshieh's blunting are unrelated to the problem addressed by the cell configuration claimed in the '409 Patent. *See supra* VI.D.1.d. Fifth, the proposed combination is the result of using hindsight bias to arbitrarily cherry pick elements from the various embodiments of Kobayashi and Hshieh to arrive at a solution with relatively uniform distances between the gates and source contacts without meaningful explanation, i.e. selecting square shape cells from among Kobayashi's and Hshieh's various cell shapes, selecting circular shaped source contact trenches from among Kobayashi's various source contact shapes, and selecting Hshieh's embodiments with all corners. *See supra* VI.D.1.c, VI.D.2.

Thus, for the same reasons discussed above in ground 4 as to limitation 1[a], Petitioner fails to present a sufficient motivation to combine Kobayashi and Hshieh in the manner claimed in limitation 6[a].

4. Petitioner Has Not Shown that Kikkawa Was a Printed Publication Before the Priority Date

As discussed in ground 2, Petitioner has not provided adequate evidence that Kikkawa qualifies as a printed publication. *Supra* VI.B.4. Thus, ground 5 also fails for this reason.

F. Ground 6: Kobayashi in view of Hshieh and knowledge of a POSITA Fails to Render the Challenged Claims Unpatentable

Claim 5 depends from claim 1. '409 Patent, cl. 5. Petitioner's arguments in ground 6 for alleged obviousness of claim 5 are based on Petitioner's arguments that Kobayashi-Hshieh renders obvious claim 1, which fail as discussed above. Pet., 67. The Petition fails to provide *any* reasoning for a motivation to combine in this ground (i.e. to combine Kobayashi, Hshieh, and the Knowledge of a POSITA). Pet., 67. Like ground 5, this failure requires that ground 6 be rejected. 315 USC § 312 (a)(3); 37 CFR § 42.6(a)(3).

To the extent that Petitioner were permitted to simply rely on their motivation to combine arguments for the separate grounds with the separate Kobayashi-Hshieh and Kobayashi-knowledge of a POSITA combinations, those arguments fail for the same reasons discussed above.

In particular, Petitioner offers no argument or evidence that the knowledge of a POSITA cures any of the deficiencies of Kobayashi-Hshieh identified above in ground 4 with respect to claim 1. That is, because Petitioner has failed to demonstrate that Kobayashi-Hshieh renders obvious claim 1, Petitioner's obviousness arguments for claim 5 in ground 6 fail for the same reasons discussed above for claim 1 in ground 4. *See supra*, VI.D.1, VI.D.2; Ex. 2021 ¶¶159-160.

Moreover, in this ground, Petitioner's arguments for the limitation added in dependent claim 5 rely on its obviousness arguments for claim 5 based on Kobayashi

and the knowledge of a POSITA in ground 3. Pet., 67. As discussed above in connection with ground 3, those obviousness arguments fail. *Supra* VI.C.2. In this ground, Petitioner makes no argument that Hshieh cures any of the deficiencies discussed above in ground 3. Accordingly, Petitioner's arguments that claim 5 is rendered obvious by Kobayashi in view of Hshieh and the knowledge of a POSITA also fail for the same reasons. Ex. 2021 ¶¶160, 162.

VII. CONCLUSION

For the above reasons, Patent Owner requests that Board hold that all challenged claims are patentable.

Date: September 16, 2024

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Certificate of Service 37 C.F.R. § 42.6(e)

The undersigned certifies that on September 16, 2024, I will cause true and correct copies of the foregoing Patent Owner's Response, and all associated exhibits or appendices referred to therein, to be served electronically upon the following attorneys who have consented to service via email. Paper No. 16.

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