

Inergy Technology, Inc. (Petitioner)
v.
Force MOS Technology Co. LTD. (Patent Owner)

Patent 7,812,409

Case IPR2024-00094

Patent Owner's Demonstratives

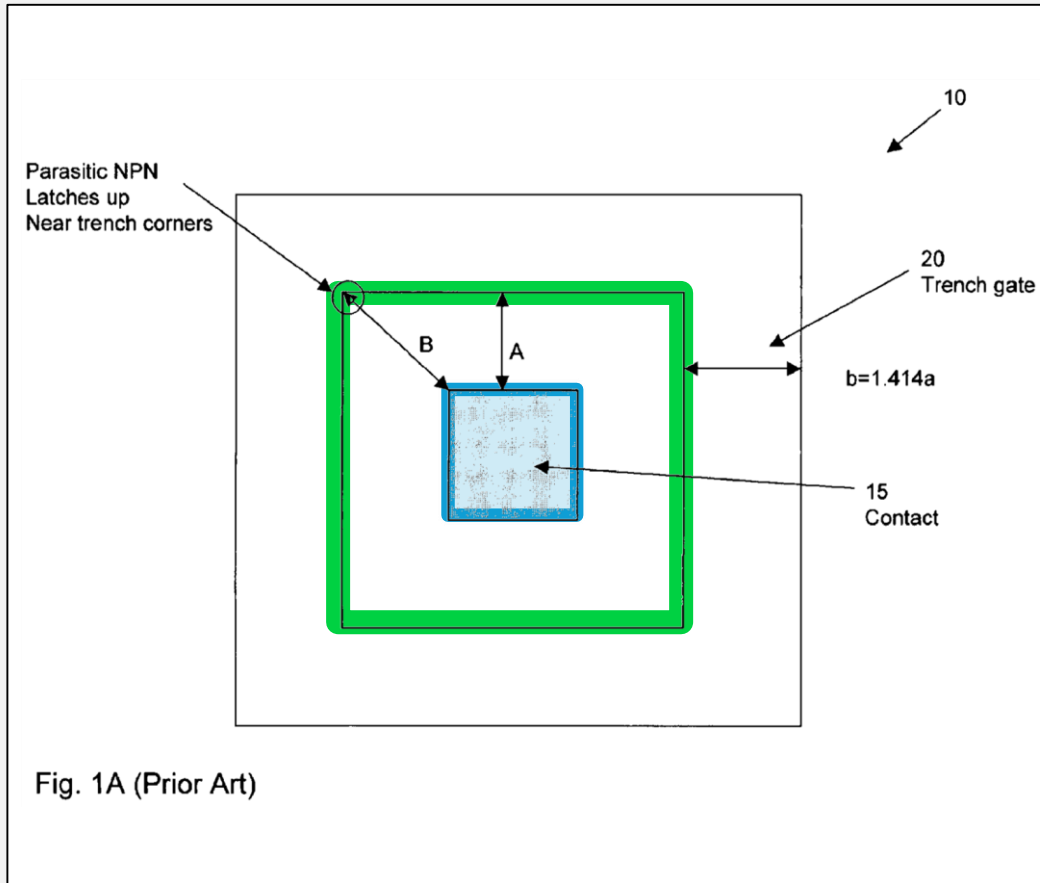
FORCEMOS Ex. 2026
Inergy v. Force MOS, IPR2024-00094

Agenda

1. Introduction to the '409 Patent
2. Claim construction of “substantially square-shaped cells with rounded corners”
3. Anticipation Grounds over Kobayashi v. claim 1 (grounds 1-3)
4. Obviousness Grounds over Kobayashi and Hshieh v. claim 1 (grounds 4-6)
5. Anticipation Grounds over Kobayashi v. claim 6 (grounds 1-3)
6. Obviousness Grounds over Kobayashi and Hshieh v. claim 6 (grounds 4-6)

Introduction to the '409 Patent

Fig. 1A (prior art)



Ex. 1001 ('409 Patent) at Fig. 1A (cited by Paper 24 at 4)

Problem

20. Therefore, the space between the metal contact 15 and the trenched gates 20 as represented by the distances A and B, plays an important role in determining the device ruggedness. For this reasons, there are weak points of the MOSFET device due the non-uniform space between the square contact and the trench in the closed cell. These weak points occur at the four corners that result in low avalanche current and reduced device ruggedness due to the parasitic N+PN latches up near the trench corners when $I \cdot R > 0.7$ volts. When bias between Base P(Pwell) and emitter N+(n+ source) of the parasitic N+PN is larger than 0.7 volts, P/N+ diode will be turned on, and thus automatically trigger turn-on of the parasitic N+PN bipolar.

Ex. 1001 ('409 Patent) at 1:45-57 (cited by Paper 24 at 4)

Fig. 3 (rounded corner embodiment)



Ex. 1001 ('409 Patent) at 2:3-7 (cited by Paper 24 at 4)

Ex. 1001 ('409 Patent) at 4:25-30 (cited by Paper 1 at 6)

Claim Construction

“substantially square-shaped cells with rounded corners”

Claim Construction: “substantially square-shaped cells with rounded corners”

Claim Term	Patent Owner’s Proposed Construction:	Petitioner’s Proposed Construction:
“substantially square-shaped cells with rounded corners”	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 rounded (i.e. having a curved shape like a portion of a circle or oval).	<u>Petition:</u> rounded corners: corners that are truncated by design layout and then rounded <u>Reply:</u> no need to interpret

Paper 24 at 10

Paper 1 at 16; Paper 26 at 2

Claim Construction: “substantially square-shaped cells with rounded corners”

The “rounded corners” are those of the “cells” (visible in top view) not the “trenched gates”

Claim 1 of '409 Patent:

[1.a] said trenched gates surrounding said transistor cells as closed cells constituting **substantially square-shaped cells with rounded corners**



2D Shape—visible in top view

Doctrine of the Last Antecedent

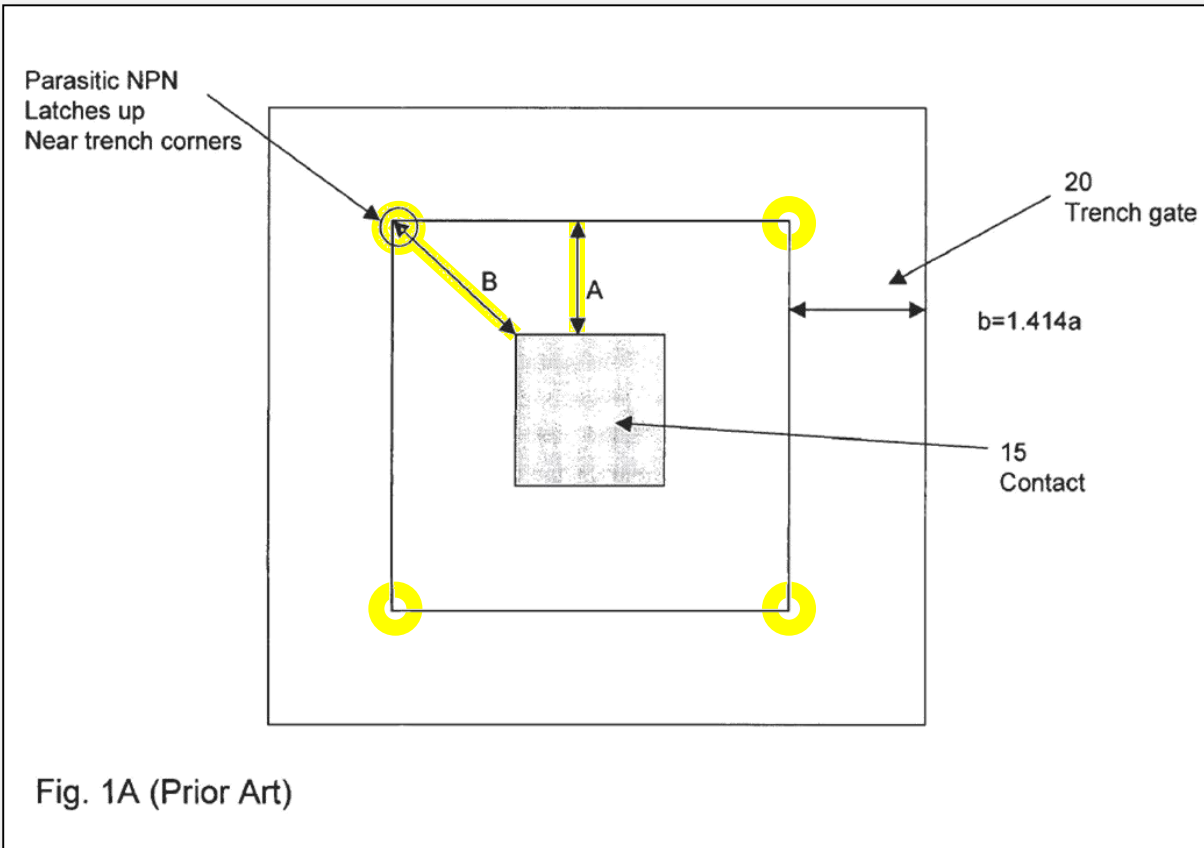
“[Under] general principles of English grammar for ... referential and qualifying words and phrases, where no contrary intention appears, refer solely to the last antecedent, which consists of the last word, phrase, or clause that can be made an antecedent without impairing the meaning of the sentence.”

Finisar Corp. v. DirectTV Grp., Inc., 523 F.3d 1323, 1336 (Fed. Cir. 2008) (cleaned up) (cited by Paper 24 at 14)

Claim Construction: “substantially square-shaped cells with rounded corners”

The “rounded corners” are those of the “cells” (visible in top view) not the “trenched gates”

’409 Patent:



Ex. 1001 (’409 Patent) at Figs. 1A (cited by Paper 24 at 14-15)

ners. Referring to FIG. 1A for a top view of a closed cell unit and FIGS. 1B and 1C for two different side cross sectional views to show the relative position arrangement of a metal source/body contact 15 from the trenched gate 20. FIG. 1B body metal contacts to n+ vertically and P+ horizontally. As illustrated in the top view of FIG. 1A both of the cells of FIGS. 1B and 1C have 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. Specifically, the

Ex. 1001 (’409 Patent) at 1:20-33 (cited by Paper 24 at 14-15)

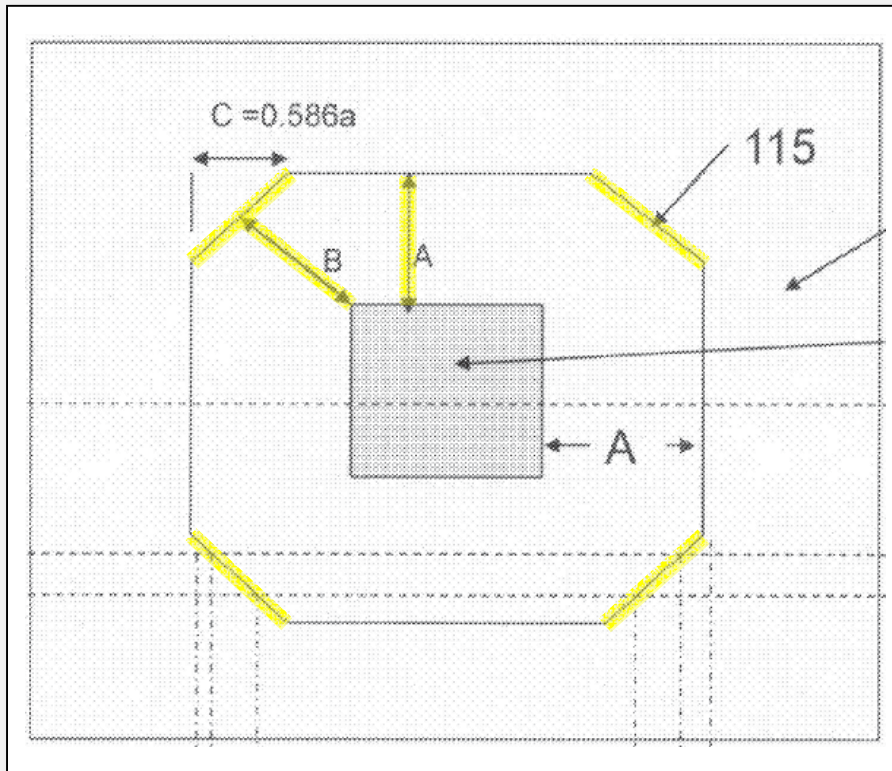
20. Therefore, the space between the metal contact 15 and the trenched gates 20 as represented by the distances A and B, plays an important role in determining the device ruggedness. For this reasons, there are weak points of the MOSFET device due the non-uniform space between the square contact and the trench in the closed cell. These weak points occur at the

Ex. 1001 (’409 Patent) at 1:45-50 (cited by Paper 24 at 14-15)

Claim Construction: “substantially square-shaped cells with rounded corners”

The “rounded corners” are those of the “cells” (visible in top view) not the “trenched gates”

'409 Patent:



Ex. 1001 ('409 Patent) at Fig. 2 (cropped)
(cited by Paper 24 at 15-16)

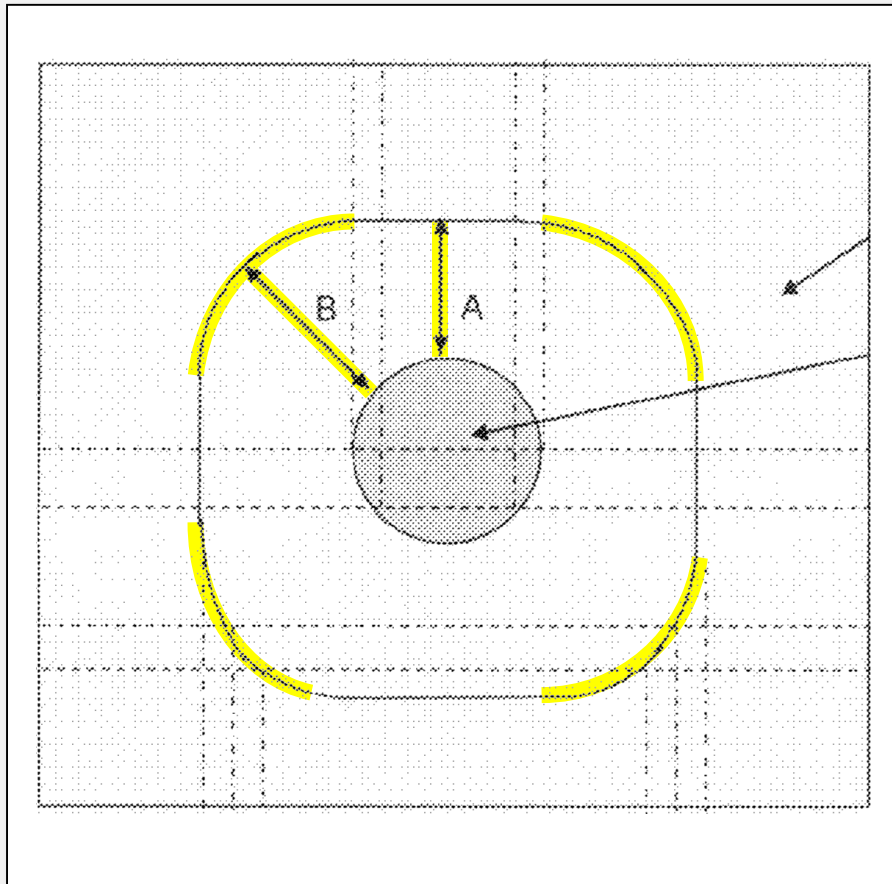
Please refer to FIG. 2 for a top view of a closed cell configuration of an improved semiconductor power device 100 of this invention. The closed cell is surrounded by a trench gate 110 that has a truncated corners 115 such that the distance B between the truncated corners to the metal contact or a doped contact region 120 is substantially equal to the distance A between the edges of the contact region 120 to the edges of the trench gate, i.e., $B=A$. There is a uniform space between the surrounding trench gate 110 and the metal contact or doped contact region 120. The weak spots around the corners in a conventional layout are therefore eliminated. FIGS. 2A, 2B and 2C show three cross sectional

Ex. 1001 ('409 Patent) at 3:32-43 (cited by Paper 24 at 15-16)

Claim Construction: “substantially square-shaped cells with rounded corners”

The “rounded corners” are those of the “cells” (visible in top view) not the “trenched gates”

'409 Patent:



Ex. 1001 ('409 Patent) at Fig. 3 (cropped) (cited by Paper 24 at 15-16)

Referring to FIG. 3 for another embodiment of this invention wherein a closed cell unit 200 of a MOSFET device includes a trench gate 210 surrounding a metal contact disposed above a doped contact region 220. The doped contact region 220 is formed with a substantial circular shape and the trench gate is formed with rounded corners 215. The distance from the edge of the circular doped contact region 220 to the trench gate 200 including the distance B to the rounded corners 215 and to the distance A to the edges of the trench gate are substantially the same, i.e., $B=A$. Therefore, the ratio of B/A is substantially kept near 1.0 and certainly smaller than 1.414. The weak spots near the corners of the trench gate that caused reduced device ruggedness are therefore eliminated. FIGS. 3A, 3B, 3C and 3D show three

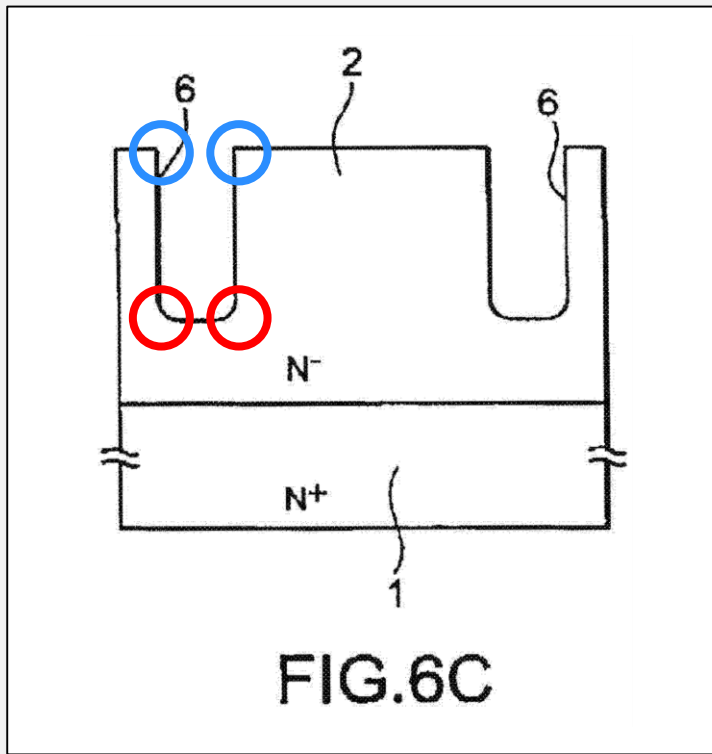
Ex. 1001 ('409 Patent) at 4:4-9) (cited by Paper 24 at 15-16)

**Kobayashi
v.
Claim 1**

Grounds 1-3

Kobayashi Does Not Disclose Limitation 1.a

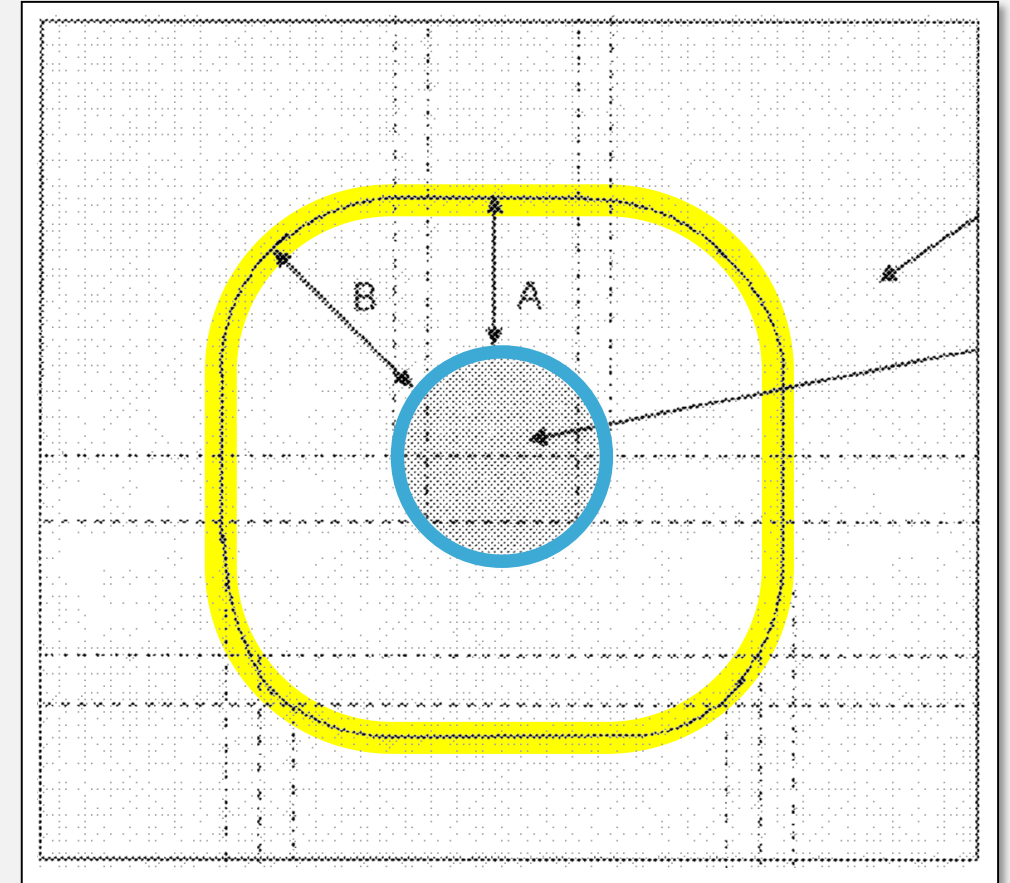
Kobayashi: side-view rounded gate trenches



Ex. 1005 (Kobayashi) at Fig. 6C (annotated)
(cited by Paper 24 at 23-25)

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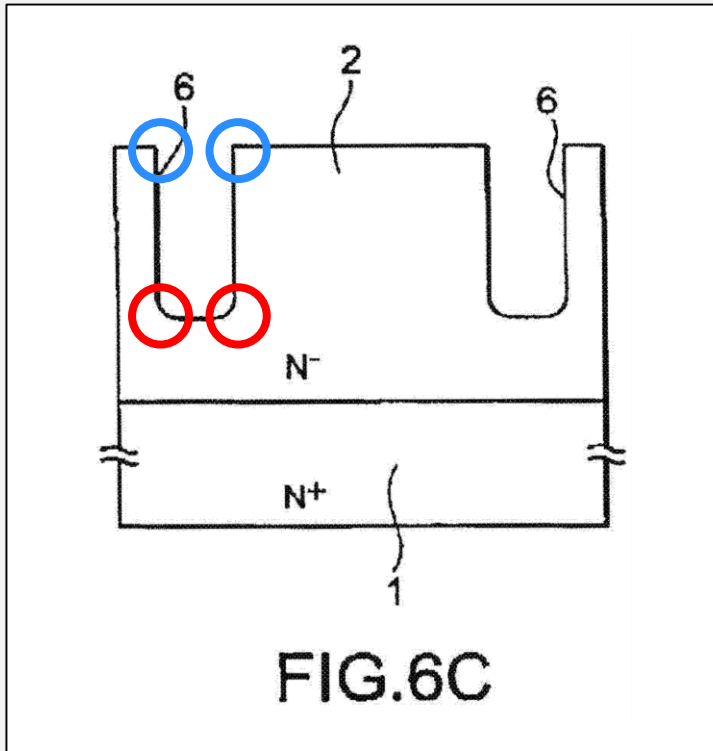
'409 Patent: “substantially square-shaped cells with rounded corners”



Kobayashi Does Not Disclose Limitation 1.a

Kobayashi's Gate Bottom/Opening Rounding is Unrelated to Cell Shape:

Kobayashi:



Ex. 1005 (Kobayashi) at Fig. 6C (annotated)
(cited by Paper 24 at 23-25)

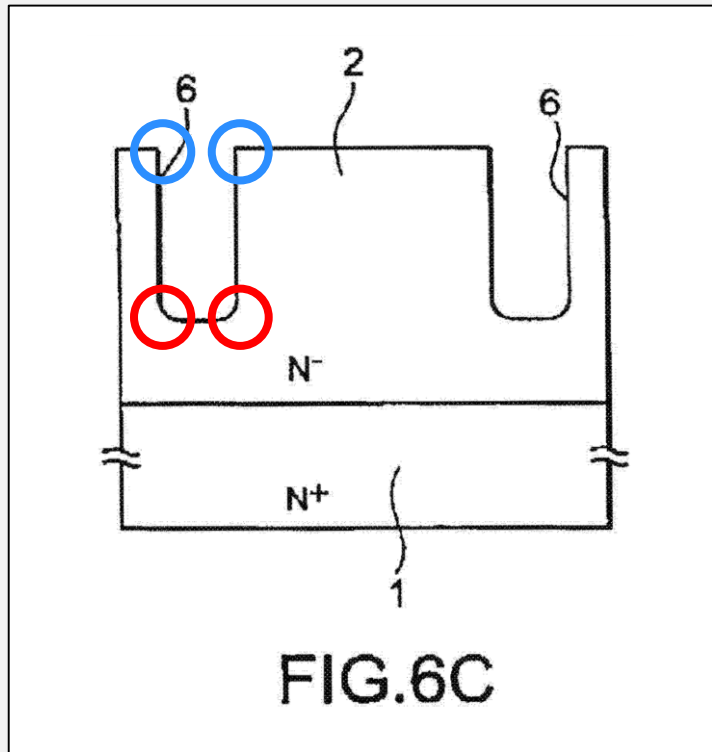
Patent Owner's Expert's Unrebutted Testimony:

perspectives. By contrast, when Kobayashi refers to rounding, it does not refer to the *cell's* corners as being rounded, but rather refers to the “corners of each [gate] trench 6 at the bottom are rounded” and “In this event, corners of each trench 6 at an opening portion may also be rounded.” *Id.* at 7:57-60 (emphasis added). Thus, Kobayashi itself demonstrates that those in the field understand that a cell's shape is defined from the *top view* perspective, and that the forms of rounding that can occur in the side view perspective are not rounding of the cell or its corners (but rather the gate trench). Other references in the field similarly show that cell

Kobayashi Does Not Disclose Limitation 1.a

Kobayashi's Rounding Is Not Consistent with "surrounding" Limitation

Kobayashi:



Ex. 1005 (Kobayashi) at Fig. 6C (annotated)
(cited by Paper 24 at 23-25)

Patent Owner's Expert's Unrebutted Testimony:

114. Dr. Liu's argument is also inconsistent with the claim language, which recites "said trench gates surrounding said transistor cells as closed cells constituting substantially square-shaped cells with rounded corners." Viewed from the top-view perspective, the gate trenches plainly surround the transistor cells. '409 patent at Fig. 3, 2:45-47, 4:20-22 (depicting and describing that cell's source and body regions surrounded by gates). But viewed from a side view perspective—as Dr. Liu's alternative "rounded corner" theory requires—the gates do not surround the bottom of the cells' source and body regions (which instead directly contact the N+ substrate layer). *Id.*, Figs. 2A-2D, 3A-3D. The same is true of Kobayashi's Fig. 6C. That is, viewed from a side view, the gates do not "surround" the cell to form a square shape, as recited, and thus corners rounded in the side view are immaterial to limitation 1.a., which requires "substantially square-shaped cells with rounded corners."

Combination of Kobayashi and Hshieh '914 v. Claim 1

Grounds 4-6

No Motivation to Combine Kobayashi and Hshieh in Manner Claimed

Petitioner and its Expert Conflate Unrelated Types of Rounding That Address Different Problems

Petition:

2. Pertinent to the same problems within the prior art.

Additionally, the '409 Patent, Kobayashi, and Hshieh are all directed to solutions to similar problems with semiconductor devices (including high power devices), such as, vulnerabilities with respect to corners of square cells. It is known that the corners of the square cells tend to induce higher peak electric fields, which would lead to a low avalanche breakdown voltage, which is undesirable.

Paper No. 1 at 57

No Motivation to Combine Kobayashi and Hshieh in Manner Claimed

Petitioner and its Expert Conflate Unrelated Types of Rounding That Address Different Problems

Petitioner's Expert:

Misleading—Kobayashi not rounding square's corners

**False—different corners, different effects
Hshieh=3D diffusion effect**

133. The '409 Patent, Kobayashi, and Hshieh are all directed to solutions to similar problems with semiconductor devices (including high power devices). This includes solutions for vulnerabilities at the corners of square cells in semiconductor devices. The corners of such square cells tend to induce higher peak electric fields, leading to a low avalanche breakdown voltage, which is undesirable. The '409 Patent acknowledges that square cell configurations with sharp corners in the prior art cause low avalanche current and reduced device ruggedness due to the parasitic N+PN latches near the corners. Ex. 1001 1:15-62. Kobayashi also discloses rounding corners of trenches in square cells. Ex. 1005, 7:57-8:4. In support of

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1012. Hshieh also discloses vulnerable punch-through weak points in the corners of square cell. Again this is due to an undesirable higher peak electric field being reached due to the same corner effect. Ex. 1006, 2:19-39.

Misleading—'409 focused on non-uniform gate-to-contact spacing

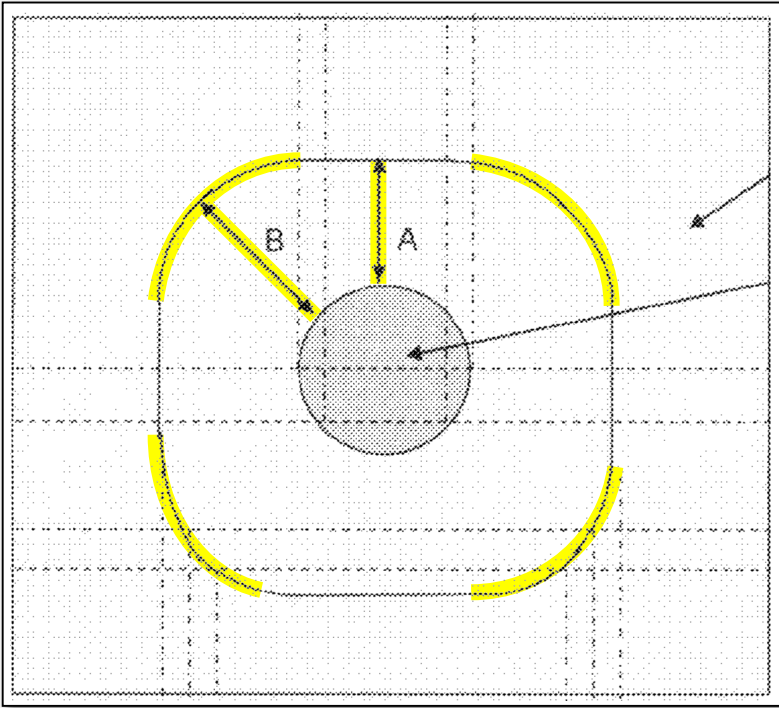
Ex. 1003, ¶133 (cited by Paper 1 at 57 and Ex. 2021, ¶¶134-138 (cited by Paper 24 at 45-48))

See Paper 24 (POR) at 15-17, 19, 23-27, 45-48, 52-54, 65; Paper 6 (Prelim Resp.) at 1, 14, 21-23, 25-27

No Motivation to Combine Kobayashi and Hshieh in Manner Claimed

Petitioner and its Expert Conflate Unrelated Types of Rounding That Address Different Problems

'409 Patent:



Ex. 1001 ('409 Patent) at Fig. 3 (cropped)
(cited by Paper No. 24 at 24, 52)

Patent Owner's Expert's Unrebutted Testimony:

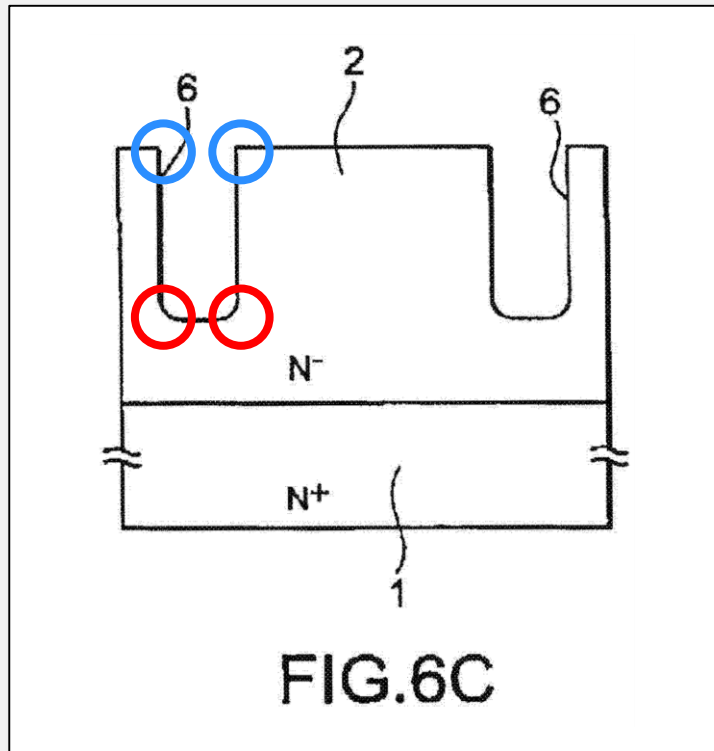
135. In my opinion, this is conflating different types of rounding that occur in different places for different purposes, a problem which repeats throughout Dr. Liu's analysis. *See, e.g.*, Ex. 1003 ¶ 135, 138, 140, 141 (conflating Kobayashi and Hsieh's "rounding" and "corners" despite different rounding of different corners for different purposes).

Ex. 2021 (Neikirk Decl.) at ¶135 (cited by Paper No. 24 at 46)

No Motivation to Combine Kobayashi and Hsieh in Manner Claimed

Kobayashi's Gate Rounding is Related to Gate Leakage from Thinned Gate Oxide

Kobayashi:



Ex. 1005 (Kobayashi) at Fig. 6C (annotated)
(cited by Paper 1 at 53)

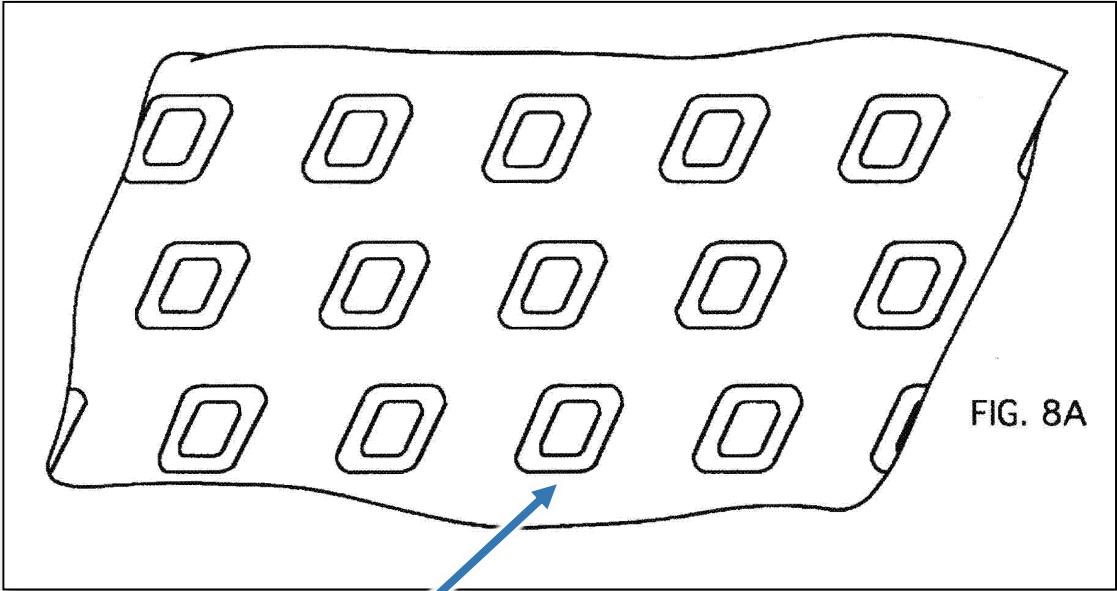
Patent Owner's Expert's Unrebutted Testimony:

137. Unlike the rounding at issue in the '409 Patent, or in Hsieh 914, the side-view rounding of gate trench corners at issue in Kobayashi 196 and Kim relate primarily to gate "leakage." Ex. 1012 at 1. In particular, in trench MOSFETs, the gate oxide can potentially become thinned in the corners. Ex. 2019 (Ng, Hong Seng. "Review on Methods for Trench MOSFET Gate Oxide Reliability and Switching Speed Improvement." ECS Transactions 27.1 (2010): 21.) at 22. This is detrimental because the gate oxide is what prohibits direct current conduction from the gate to drain (in proper operation of a MOSFET the gate signal is intended to control source-to-drain charge flow via the field effect). At sufficient voltages, if the gate oxide is too thin, leakage can occur from the gate to the base layer via tunneling, resulting in unwanted power dissipation and potentially device destruction. *Id.* at 23; Ex. 2018

No Motivation to Combine Kobayashi and Hshieh in Manner Claimed

Hshieh Teaches Away—Hshieh’s Basic Objective Is To Use Non-Orthogonal Parallelograms

Hshieh:



Ex. 1006 (Hshieh '914) at Fig. 8A
(cited by Paper 1 at 59)

Non-Orthogonal Parallelograms

Specifically, it is an object of the present invention to provide a new and improved MOSFET cell topology wherein the packing density is increased by manufacturing the transistor cells as non-orthogonal parallelograms wherein the packing density is increased with the same total channel width formed in a smaller cell area when compared to that of square cells as that commonly used in the prior art such that the cell size can be further reduced without sacrificing the total channel width.

Ex. 1006 (Hshieh '914) at 2:64-3:5 (cited by Paper 24 at 48-49)

No Motivation to Combine Kobayashi and Hshieh in Manner Claimed

Hshieh's Top-View Rounding Is Related to 3D Diffusion Phenomenon

Hshieh:

In 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, similar to that discussed above in U.S. Pat. No. 5,304,831 by Yilmaz et al., the sharp corners of the polysilicon openings can be either blunted or rounded as that shown in FIGS. 6A and 6B respectively. Compared to the cell topology disclosed by

Ex. 1006 (Hshieh '914) at 5:3-9 (cited by Paper 24 at 53)

Patent Owner's Expert's Unrebutted Testimony:

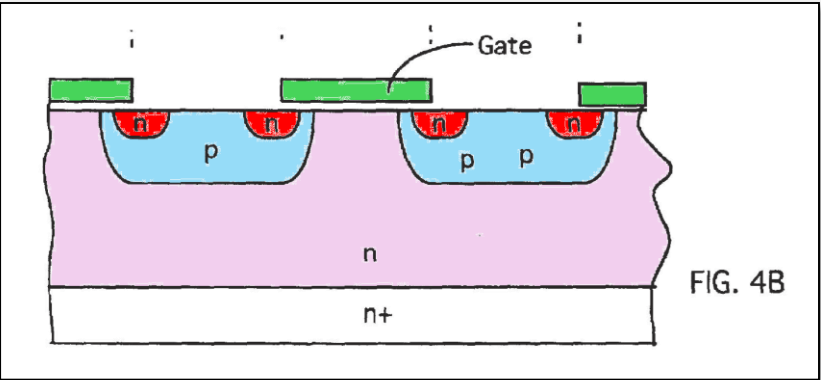
138. Hsieh 914 uses rounding in a different way, and at a different place, and in a manner unrelated to the type and purpose of rounding in Kim and Kobayashi. In particular, Hsieh 914 is concerned with the three dimensional diffusion phenomenon, which causes short channel length in the corners of cells, particularly for Hsieh's non-orthogonal parallelograms. Ex. 1006 at 2:19-34. I discuss the three-dimensional diffusion effect further below, but, suffice to say, that type of rounding is entirely unrelated to the side view trench corner bottom / opening rounding at issue in Kobayashi and Kim.

Ex. 1006 (Neikirk Decl.) at ¶138 (cited by Paper No. 24 at 46)

No Motivation to Combine Kobayashi and Hshieh in Manner Claimed

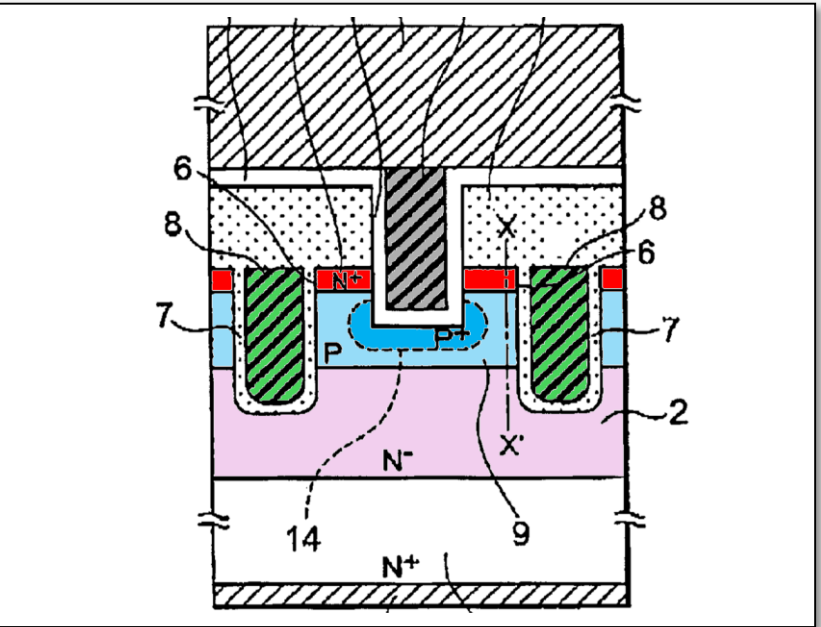
Structure of Hshieh's Rounded-Corner Embodiments Is Unrelated to Structure of '409 Patent or Kobayashi

Structure of Hshieh's Rounded Embodiments:



Ex. 1006 (Hshieh) at Fig. 4B (edited) (cited by Paper 24 at 53)

Kobayashi's Structure:



See Paper 24 (POR) at 52-54

Patent Owner's Expert's Unrebutted Testimony:

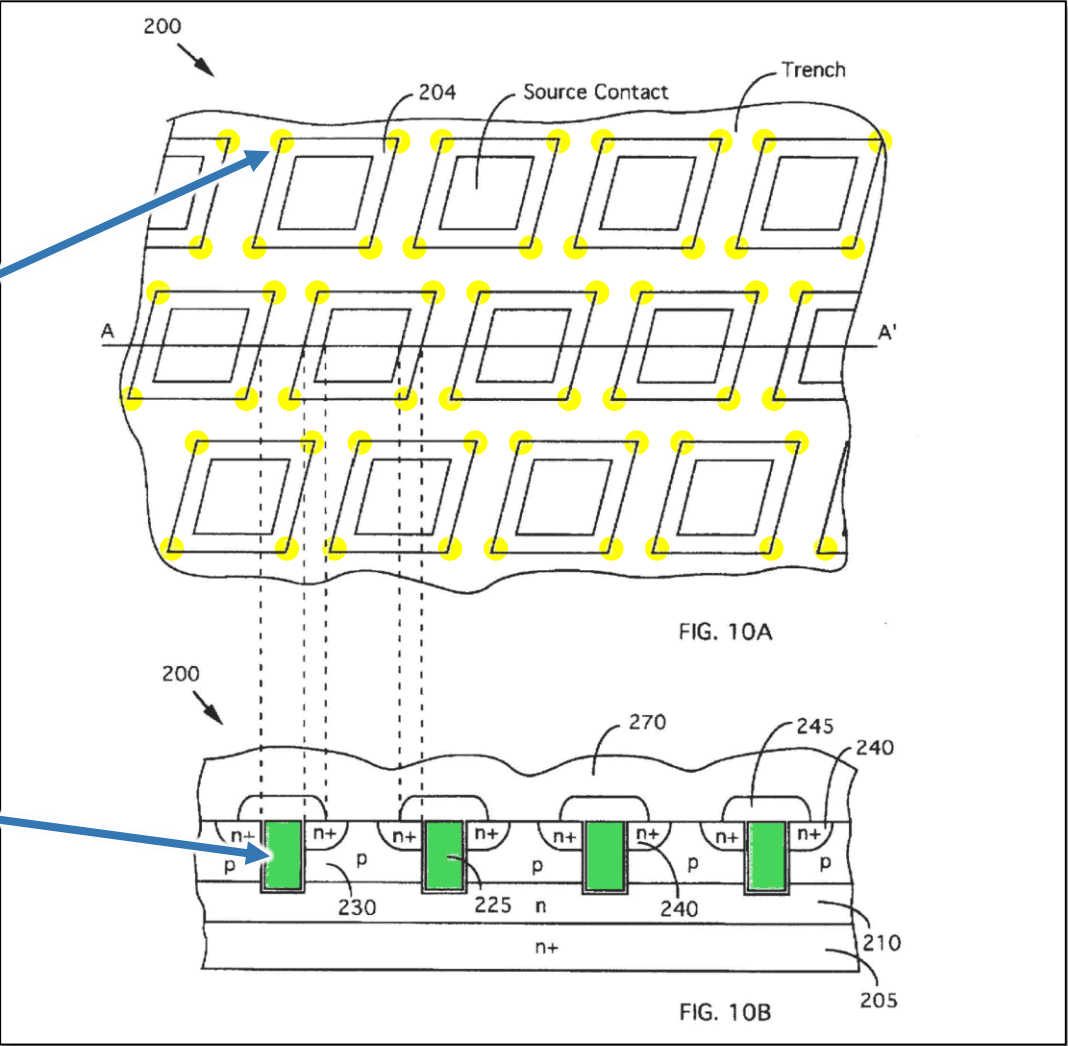
145. By contrast, Hshieh's structure is fundamentally different. Nearly all of Hsieh's disclosed embodiments lack trench gates. Ex. 1006, Figs. 6A-8B. Indeed, none of the depicted or disclosed embodiments with rounded corners in Hsieh's specification have trench gates. Compare Ex. 1006, Figs. 6A-8B with id.;
...
trenches).⁴ Moreover, all of Hshieh's embodiments entirely lack trenched source contacts. That is, unlike the '409 Patent which has both "trenched gates" and a
...
914) at Fig. 4B, 9D, 10B, 7:26-8:5. 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 semiconductor material and contacts the semiconductor material through "source openings" in the oxide layer. Id. Figs. 4B, 9D, 10B, 1:45-51, 3:38-42, 6:52-56, 7:26-30, 7:56-60. Thus, not surprisingly, Hshieh's discussion of "rounding" is not concerned with problems relating to trenched source contacts.

No Motivation to Combine Kobayashi and Hshieh in Manner Claimed

Hshieh Does Not Depict Trench Gate Embodiments as Using Rounded Corners

Sharp Corners

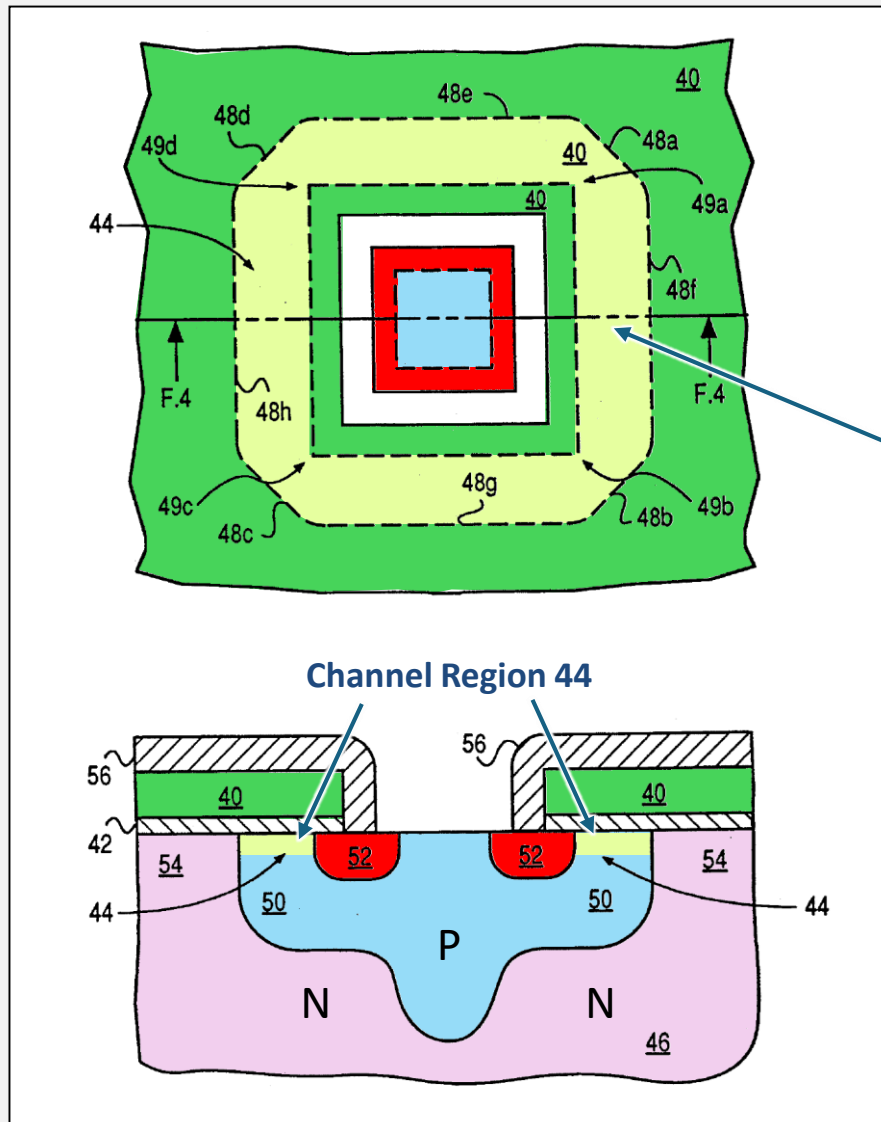
Trench Gates



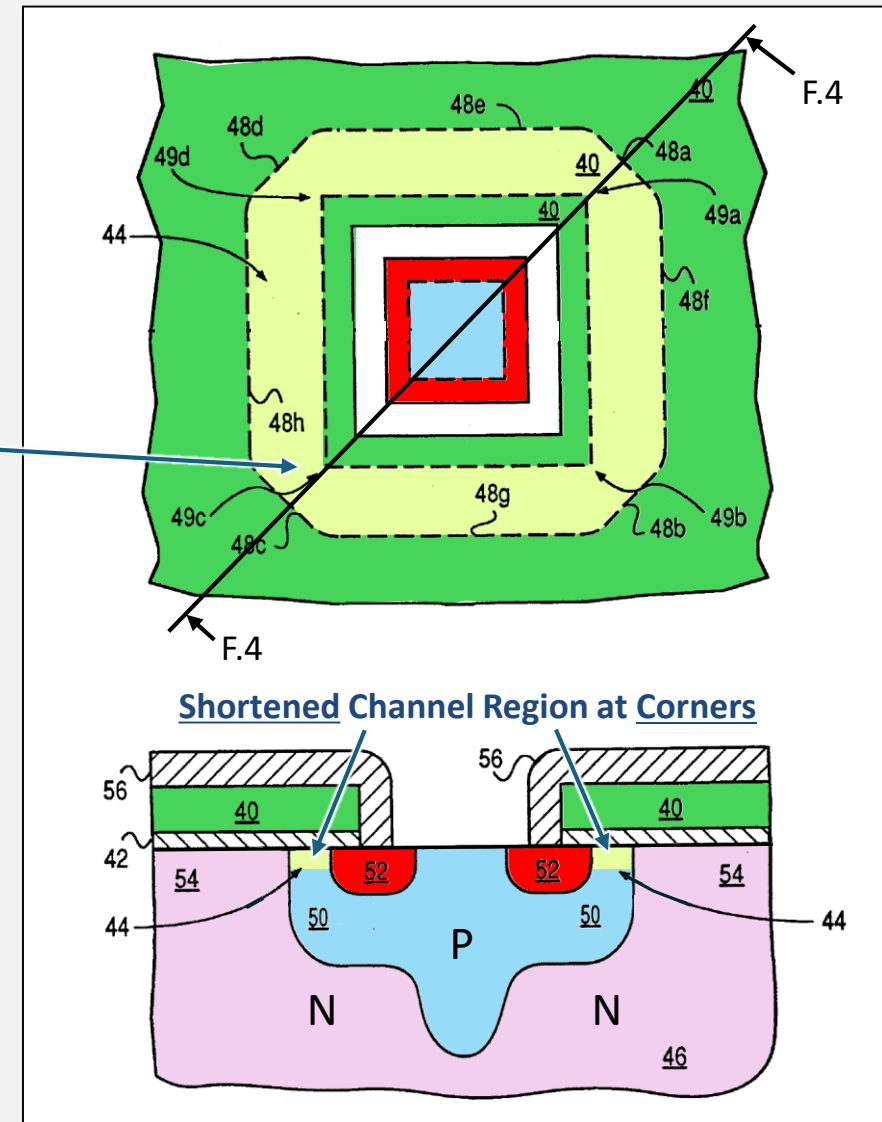
Ex. 1006 (Hshieh '914) at Fig. 10A and Fig. 10B (cited by Paper 24 at 53)

Hshieh Only Discloses Rounding to Address Short Channels in Corners of Planar MOSFETs from 3D Diffusion Phenomena

Planar MOSFET, Cross-section in Middle:



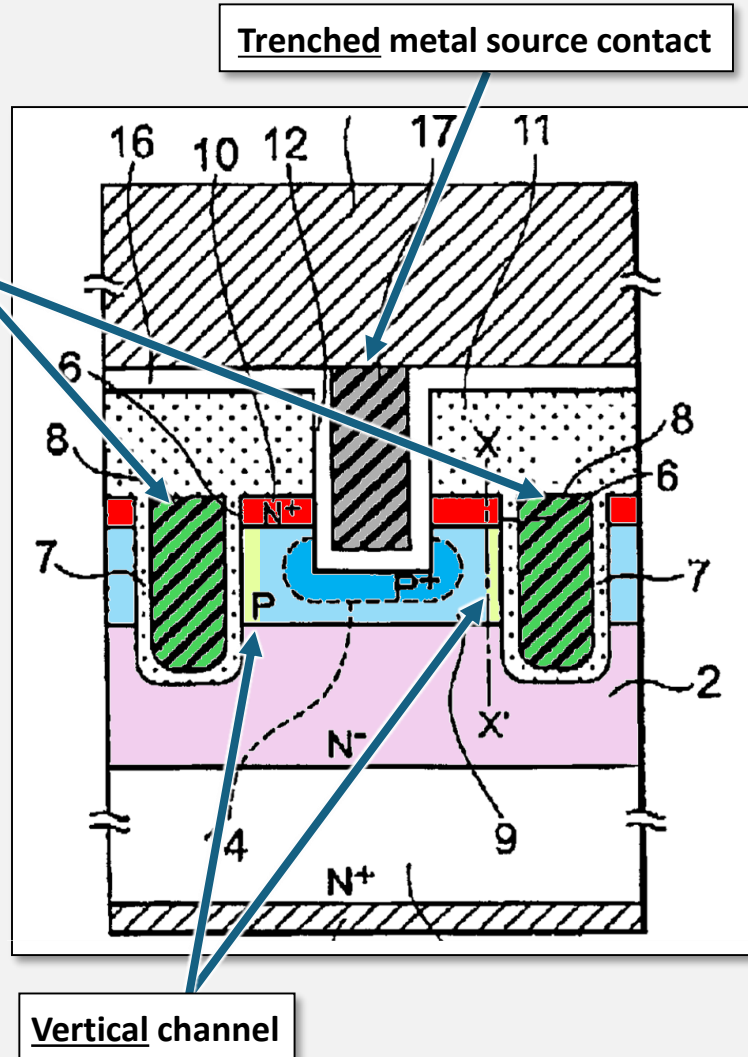
Planar MOSFET, Cross-section at Corners:



No Motivation to Combine Kobayashi and Hshieh in Manner Claimed

Short Corners Caused by 3D Diffusion Phenomena Does Not Affect Kobayashi

Kobayashi:



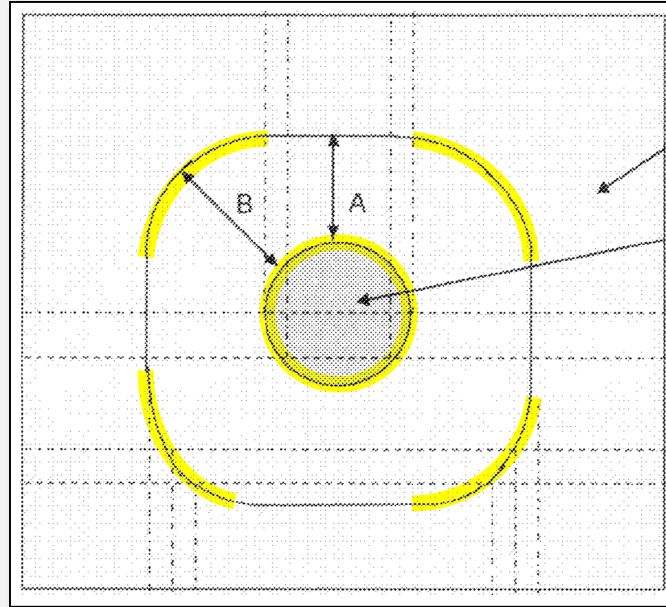
Patent Owner's Expert's Unrebutted Testimony:

Id. at 8:21-46, Fig. 7A. Because the channel length of Kobayashi's vertical channel is determined by the vertical depth of implantation and diffusion of the source layer and body region, the problem of the three dimensional diffusion phenomena—the differential rates of horizontal diffusion of P and N type dopants in corners—is irrelevant to the structure, design, or fabrication of Kobayashi 196's MOSFET. Accordingly, in my opinion, Dr. Liu has not identified any motivation to combine Hshieh 914's corner rounding/blunting that has any applicability to Kobayashi 196.

Ex. 2021 (Neikirk Decl.) at ¶150 (cited by Paper No. 24 at 55)

Petitioner's Arbitrary Cherry-Picking of Disclosures

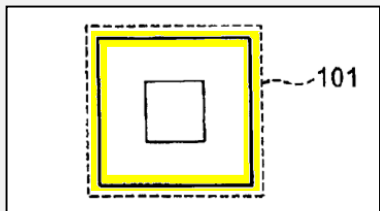
Improved Uniformity of Contact-to-Gate Distance



Ex. 1001 ('409 Patent) at Fig. 3 (cropped)

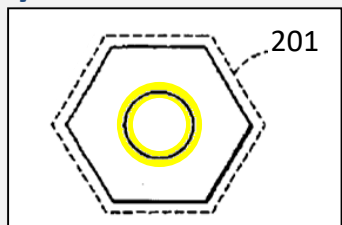
Petitioner's Arbitrary Cherry-Picking of Disclosures

Kobayashi's Square Cells



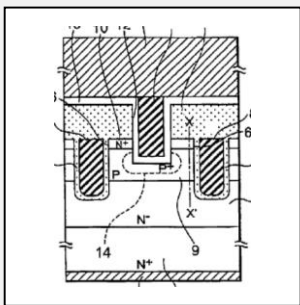
Ex. 1003 at Fig. 3A (cropped)

Kobayashi's Circular Contacts



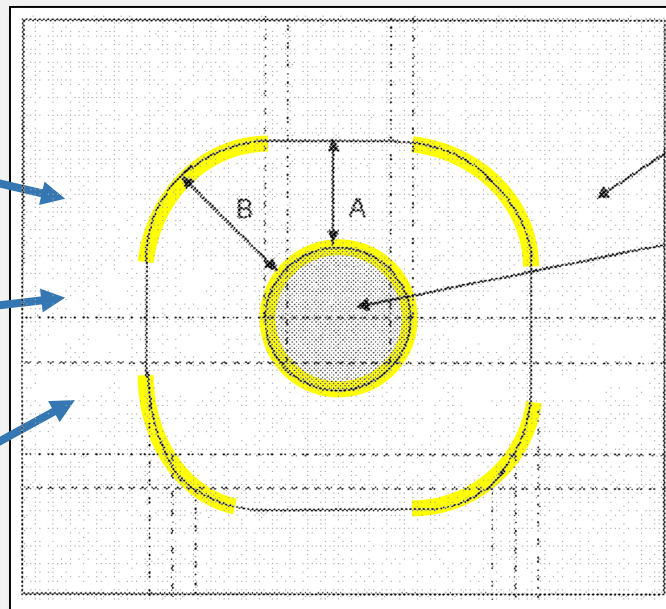
Ex. 1003 at Fig. 4A (cropped)

Kobayashi's Trenched Gate, Trenched Contact Structure



Ex. 1003 at Fig. 5A (cropped)

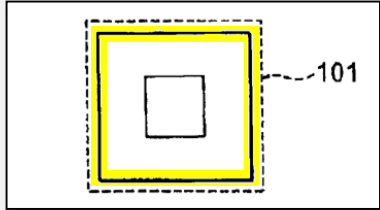
Improved Uniformity of Contact-to-Gate Distance



Ex. 1001 ('409 Patent) at Fig. 3 (cropped)

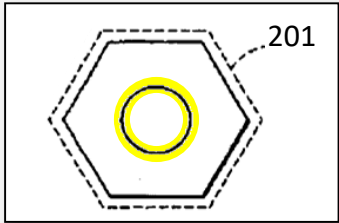
Petitioner's Arbitrary Cherry-Picking of Disclosures

Kobayashi's Square Cells



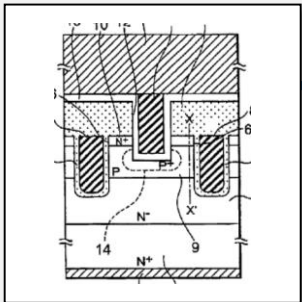
Ex. 1003 at Fig. 3A (cropped)

Kobayashi's Circular Contacts



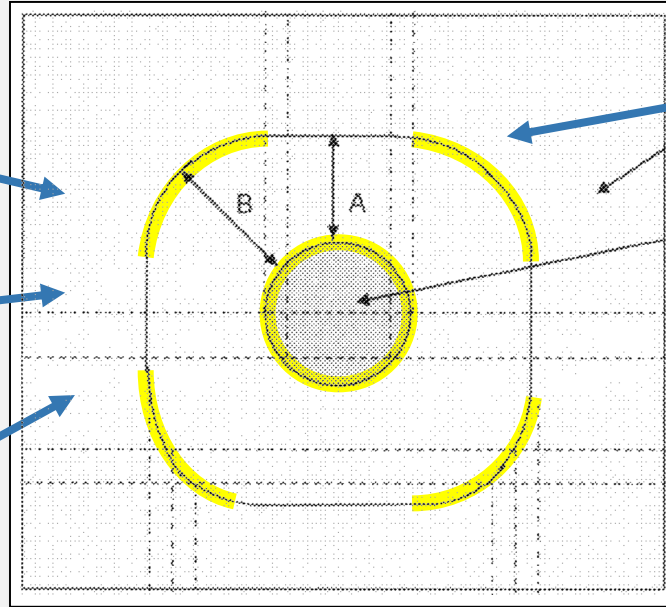
Ex. 1003 at Fig. 4A (cropped)

Kobayashi's Trenched Gate, Trenched Contact Structure



Ex. 1003 at Fig. 5A (cropped)

Improved Uniformity of Contact-to-Gate Distance



Ex. 1001 ('409 Patent) at Fig. 3 (cropped)

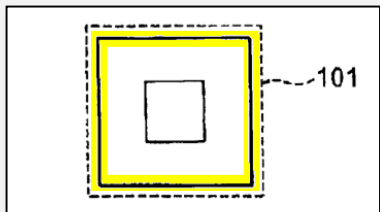
Hshieh's Four Rounded Corners



Ex. 1006 at Fig. 8A (cropped)

Petitioner's Arbitrary Cherry-Picking of Disclosures

Kobayashi's Square Cells



Ex. 1003 at Fig. 3A (cropped)

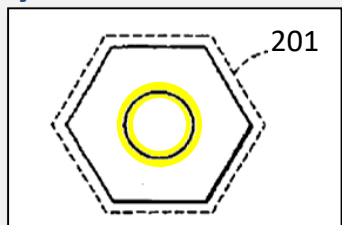
Improved Uniformity of Contact-to-Gate Distance

Hshieh's Four Rounded Corners

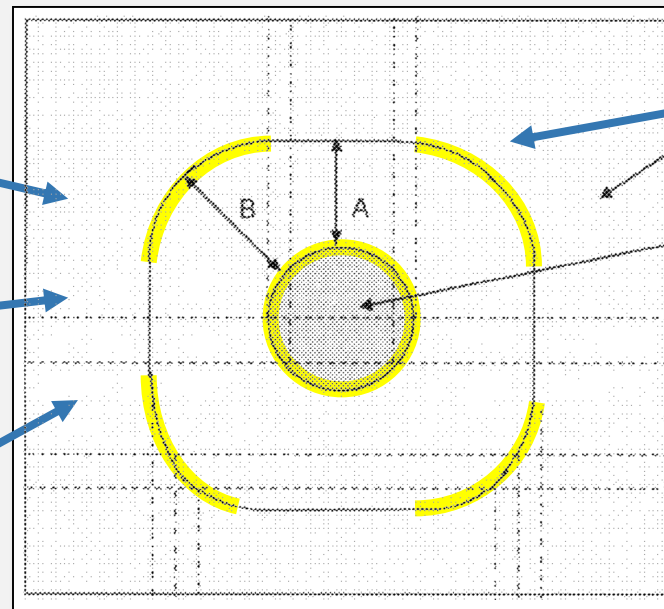


Ex. 1006 at Fig. 8A (cropped)

Kobayashi's Circular Contacts

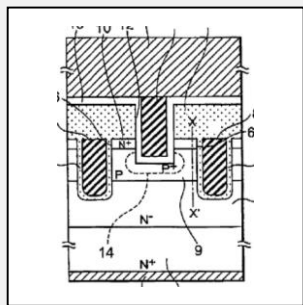


Ex. 1003 at Fig. 4A (cropped)



Ex. 1001 ('409 Patent) at Fig. 3 (cropped)

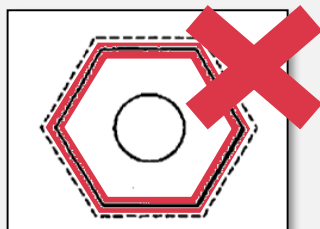
Kobayashi's Trenched Gate, Trenched Contact Structure



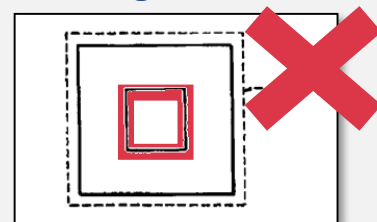
Ex. 1003 at Fig. 5A (cropped)

Kobayashi's Square, Hexagonal, and Octagonal Contacts

Kobayashi's Hexagon Cells



Ex. 1003 at Fig. 4A (cropped)



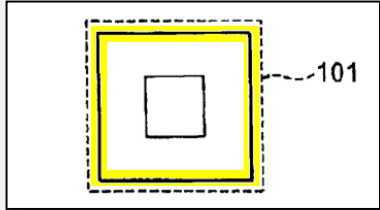
Ex. 1003 at Fig. 3A (cropped)

DEMONSTRATIVE EXHIBIT – NOT EVIDENCE

Petitioner's Arbitrary Cherry-Picking of Disclosures

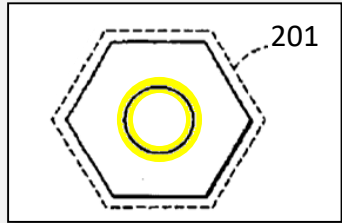
Improved Uniformity of Contact-to-Gate Distance

Kobayashi's Square Cells



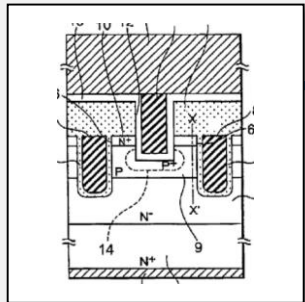
Ex. 1003 at Fig. 3A (cropped)

Kobayashi's Circular Contacts



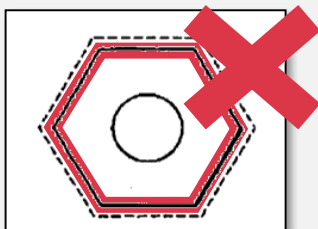
Ex. 1003 at Fig. 4A (cropped)

Kobayashi's Trenched Gate, Trenched Contact Structure



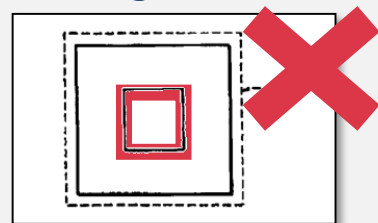
Ex. 1003 at Fig. 5A (cropped)

Kobayashi's Hexagon Cells



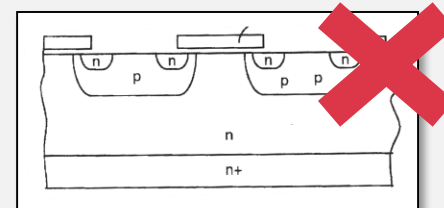
Ex. 1003 at Fig. 4A (cropped)

Kobayashi's Square, Hexagonal, and Octagonal Contacts



Ex. 1003 at Fig. 3A (cropped)

Hshieh's Planar MOSFET



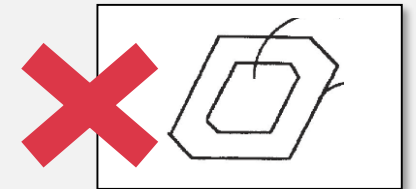
Ex. 1006 at Fig. 4B (cropped)

Hshieh's Four Rounded Corners



Ex. 1006 at Fig. 8A (cropped)

Hshieh's Blunted Corners



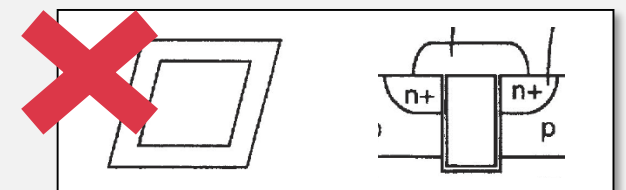
Ex. 1006 at Fig. 6A (cropped)

Hshieh's Only Two Rounded Corners

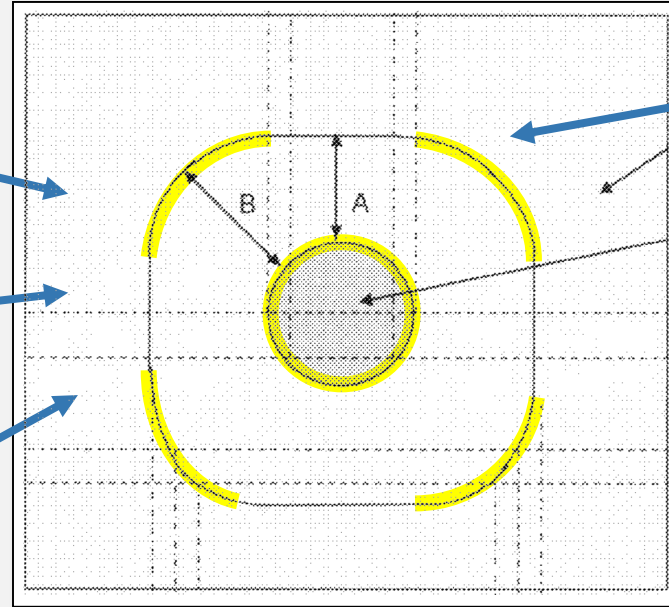


Ex. 1006 at Fig. 6B (cropped)

Hshieh's Trench-Gate, Non-trenched Contact Structure With Sharp Corners



Ex. 1006 at Fig. 10A and 10B (cropped)



Ex. 1001 ('409 Patent) at Fig. 3 (cropped)

DEMONSTRATIVE EXHIBIT – NOT EVIDENCE

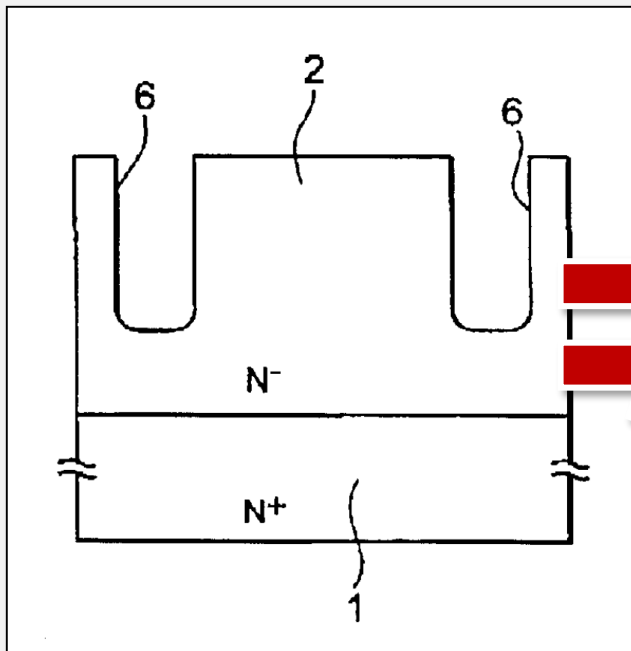
**Kobayashi
v.
Claim 6**

Kobayashi Does Not Disclose Limitation 6.a

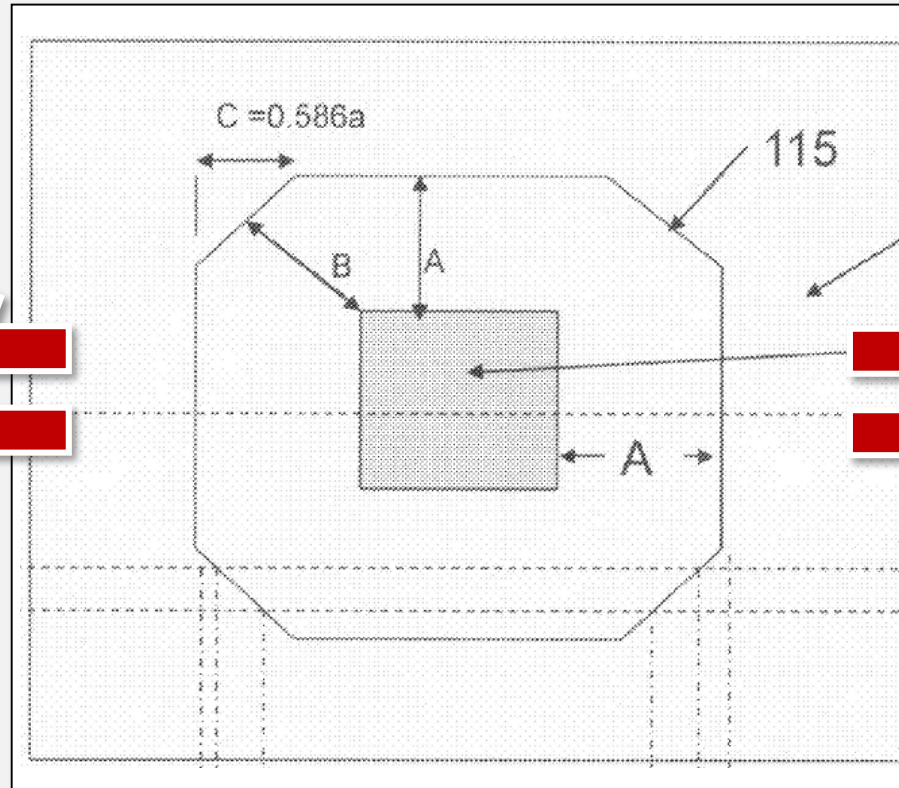
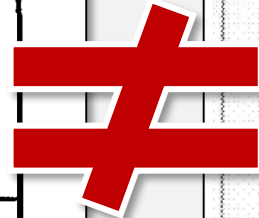
Rounding Is Not Truncating; Hexagons Are Not Substantially Square Shaped with Truncated Corners

'409 Patent: substantially square-shaped cells with truncated corners

Kobayashi's Side-view Rounded Gates:

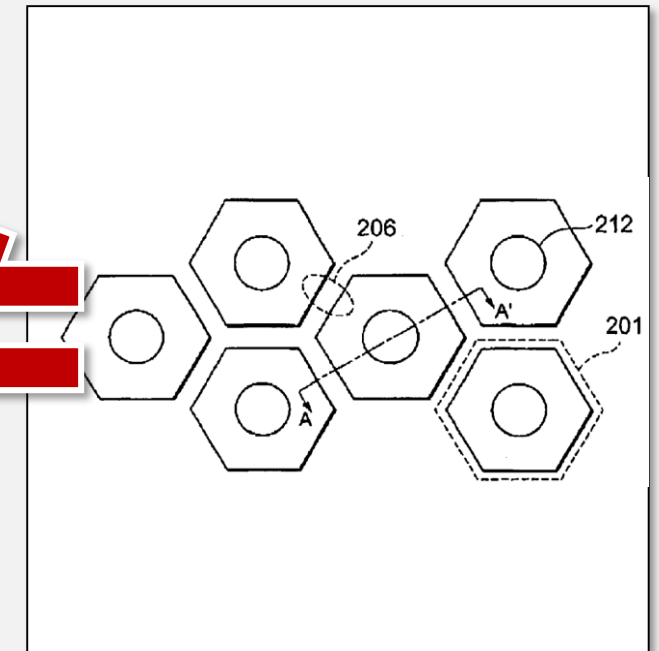


Ex. 1005 (Kobayashi) at Fig. 6C
(cited by Paper 1 at 27)

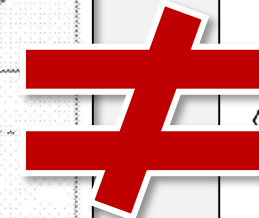


Ex. 1001 ('490 Patent) at Fig. 2 (cropped)(cited by Paper 24 at 36)

Kobayashi's Hexagons:



Ex. 1005 (Kobayashi) at Fig. 4A
(cited by Paper 1 at 26)



**Combination of Kobayashi and Hshieh '914
v.
Claim 6**

No Motivation to Combine Kobayashi and Hshieh in Manner Claimed

Same arguments as Kobayashi and Hshieh 914 v. claim 1 apply to claim 6

- Kobayashi's side-view rounding unrelated to Hshieh's top view blunting
- Hshieh's blunted embodiments very different from Kobayashi
- No evidence or argument that Kobayashi benefits from Hshieh's blunting to address 3D diffusion problem
- Relies on hindsight cherry-picking of disclosures