Trials@uspto.gov
571-272-7822

Paper 25
Entered: June 1, 2017

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

INTEL CORPORATION
and
QUALCOMM INCORPORATED, GLOBALFOUNDRIES INC., GLOBALFOUNDRIES U.S. INC., GLOBALFOUNDRIES DRESDEN MODULE ONE LLC & CO. KG, GLOBALFOUNDRIES DRESDEN MODULE TWO LLC & CO. KG,
Petitioner,

v.

DSS TECHNOLOGY MANAGEMENT, INC.,
Patent Owner.

Case IPR2016-00287[1]
Patent 6,784,552 B2

Before BRYAN F. MOORE, BRIAN J. McNAMARA, and MINN CHUNG, *Administrative Patent Judges.*

CHUNG, *Administrative Patent Judge.*

FINAL WRITTEN DECISION
35 U.S.C. § 318(a) and 37 C.F.R. § 42.73

[1] Case IPR2016-01311 has been joined with this proceeding.

I. INTRODUCTION

In this *inter partes* review, instituted pursuant to 35 U.S.C. § 314, Intel Corporation, Qualcomm Incorporated, Globalfoundries Inc., Globalfoundries U.S. Inc., Globalfoundries Dresden Module One LLC & Co. KG, and Globalfoundries Dresden Module Two LLC & Co. KG (collectively, "Petitioner") challenge the patentability of claims 1–7 (the "challenged claims") of U.S. Patent No. 6,784,552 B2 (Ex. 1001, "the '552 patent"), owned by DSS Technology Management, Inc. ("Patent Owner"). The Board has jurisdiction under 35 U.S.C. § 6. This Final Written Decision is entered pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73. We base our decision on the preponderance of the evidence. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d). With respect to the grounds instituted in this trial, we have considered the papers submitted by the parties and the evidence cited therein. For the reasons discussed below, we determine Petitioner has shown by a preponderance of the evidence that claims 1–7 of the '552 patent are unpatentable.

A. Procedural History

On December 8, 2015, Intel Corporation filed a Petition (Paper 2, "Pet.") requesting *inter partes* review of claims 1–7 of the '552 patent. Patent Owner filed a Preliminary Response (Paper 7, "Prelim. Resp."). On June 8, 2016, we instituted an *inter partes* review of claims 1–7 of the '552 patent based on the following specific grounds (Paper 11, "Dec. on Inst.," 28–29).

Claim(s) Challenged	Statutory Basis	Reference(s)
1, 2, and 4–7	§ 102(b)	Heath[2]
3	§ 103(a)	Heath, Hawley,[3] and Chappell[4]

After institution, Qualcomm Incorporated, Globalfoundries Inc., Globalfoundries U.S. Inc., Globalfoundries Dresden Module One LLC & Co. KG, and Globalfoundries Dresden Module Two LLC & Co. KG (collectively, "Qualcomm") filed a petition requesting *inter partes* review of claims 1–7 of the '552 patent on the same grounds asserted by Intel Corporation, accompanied by a timely motion seeking joinder with this proceeding. IPR2016-01311, Papers 3 (petition), 4 (motion for joinder).[5] Patent Owner did not oppose the joinder. We instituted an *inter partes* review and joined it with the present proceeding. Papers 18, 19.

On September 7, 2016, Patent Owner filed a Patent Owner Response (Paper 20, "PO Resp.") that contained no citations to evidence and no argument, other than noting that, in contrast to the standard applied in reaching a decision to institute (i.e., a reasonable likelihood Petitioner will prevail on its challenge to patentability of a claim), the standard for reaching

[2] Ex. 1003, U.S. Patent No. 4,686,000 (Aug. 11, 1987) ("Heath").

[3] Ex. 1004, European Patent Application Publication No. 0592078 A1 (Apr. 13, 1994) ("Hawley").

[4] Ex. 1005, U.S. Patent No. 5,541,427 (July 30, 1996) ("Chappell").

[5] Because Qualcomm's petition in IPR2016-01311 is identical in all substantive aspects to the Petition in this proceeding (*see* Paper 18, 8–9), we cite only to the Petition throughout this Final Written Decision.

a final decision is whether the Petitioner proved unpatentability by a preponderance of the evidence. PO Resp. 2. Patent Owner then stated that it "defers to the Board to make this determination based on its impartial analysis of the prior art and Petitioners' arguments." *Id.*

In its Reply (Paper 21, "Pet. Reply") filed on December 7, 2016, Petitioner stated that Patent Owner has not cross-examined Petitioner's expert, John C. Bravman, Ph.D., or provided any testimony that contradicts Dr. Bravman's testimony, and that the challenged claims should be found unpatentable. Pet. Reply 1–2.

No hearing was held because we determined oral argument is not necessary to render a final written decision in this proceeding. *See* Paper 24, 2.

B. Related Proceedings

According to the parties, the '552 patent is the subject of the following patent infringement cases: *DSS Tech. Mgmt., Inc. v. Intel Corp.*, Case No. 6:15-cv-130-JRG (E.D. Tex.); *DSS Tech. Mgmt., Inc. v. Samsung Elec. Co., Ltd.*, Case No. 6:15-cv-690 (E.D. Tex.); *DSS Tech. Mgmt., Inc. v. SK Hynix, Inc.*, Case No. 6:15-cv-691 (E.D. Tex.); and *DSS Tech. Mgmt., Inc. v. Qualcomm, Inc.*, Case No. 6:15-cv-692 (E.D. Tex.). Pet. 7; Paper 6, 2–3. In related proceedings before the Board, we instituted *inter partes* reviews of claims 8–12 of the '552 patent in IPR2016-00288 and IPR2016-01314.[6] The '552 patent is also the subject of an instituted trial proceeding *Samsung Elec. Co., Ltd. v. DSS Tech. Mgmt., Inc.*, Case IPR2016-00782.

[6] Case IPR2016-01314 has been joined with IPR2016-00288.

Additionally, we instituted *inter partes* reviews of claims of U.S. Patent No. 5,965,924 in *Intel Corp. v. DSS Tech. Mgmt., Inc.*, Cases IPR2016-00289, IPR2016-00290, IPR2016-01312, and IPR2016-01313.[7]

II. THE '552 PATENT

A. Described Invention

The '552 patent describes a process of semiconductor device fabrication and a structure of a semiconductor device having "substantially rectangular" lateral insulating spacers adjacent to gate electrodes. Ex. 1001, Abstract. The '552 patent defines the term "substantially rectangular" to mean that "a side of the spacer has an angle relative to the substrate surface of more than 85°." *Id.* at col. 8, ll. 40–42.

Figure 4(D) of the '552 patent is reproduced below.

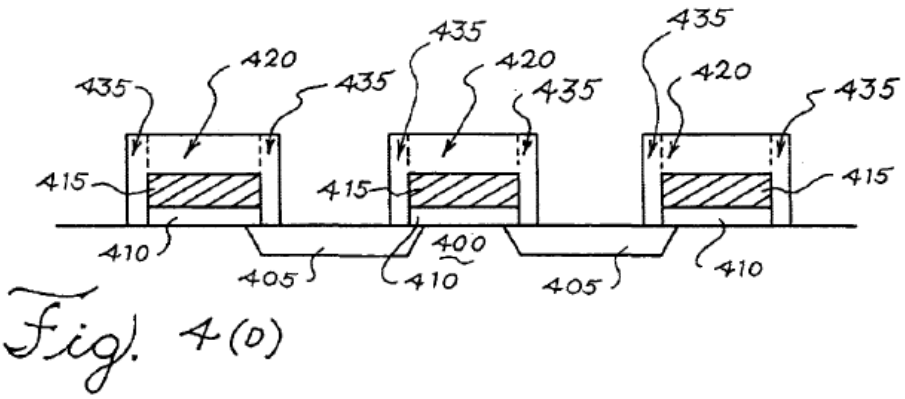


Fig. 4(D)

Figure 4(D) illustrates a cross-sectional view of a series of gates 415 (also called conducting layers or polysilicon layers) completely encapsulated in insulating material 420, e.g., TEOS (tetraethyl orthosilicate glass), where

[7] Cases IPR2016-01312 and IPR2016-01313 have been joined with IPR2016-00290 and IPR2016-00289, respectively.

spacers or spacer portions 435 of the insulating material adjacent to the gates have substantially rectangular profiles. *Id.* at col. 9, ll. 9–13; col. 11, ll. 40–46. As shown in Figure 4(D), gates 415 are insulated from sources or drains 405 by insulating dielectric layers 410. *See id.* at col. 10, ll. 49–50. The '552 patent describes a process of making high quality contacts to the sources or drains, such as "self-aligned" contacts, by etching structures over substrate 400 and sources or drains 405. *Id.* at col. 7, ll. 19–22; col. 8, ll. 4–6.

Figure 4(I) of the '552 patent is reproduced below.

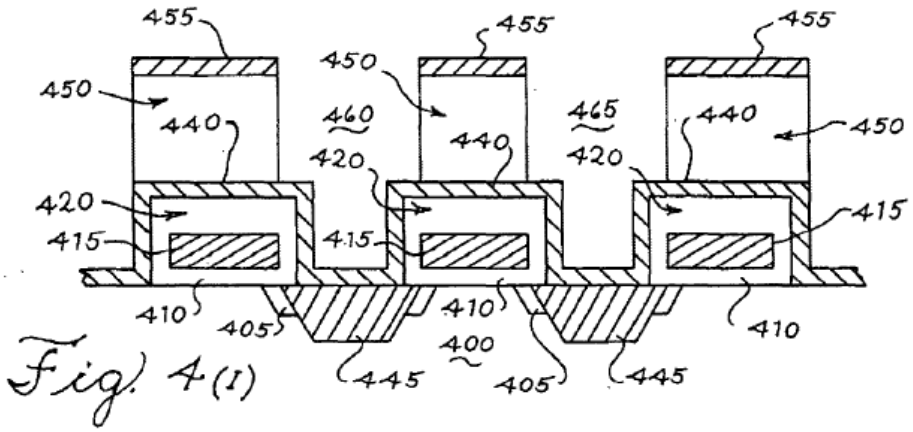


Figure 4(I) illustrates additional structures deposited and etched over the structure described in Figure 4(D), such as second dielectric layer 440 (called etch stop layer), blanket layer 450, and photoresist mask layer 455. *Id.* at col. 9, ll. 33–39; col. 11, ll. 63–65; col. 12, ll. 34–42. According to the '552 patent, etch stop layer 440, e.g., silicon nitride layer 440, depicted in Figure 4(I) is distinct or different from the underlying TEOS insulating layer. *Id.* at col. 12, ll. 10–11. The etch stop layer protects the underlying

TEOS layer when blanket layer 450 made of BPTEOS[8] is etched away to create contact openings 460 and 465 above source or drain 445. *See id.* at col. 12, ll. 36–42; col. 4, ll. 41–59.

A second etch is then performed to remove etch stop layer 440 covering source or drain 445 in contact openings 460 and 465. *Id.* at col. 12, ll. 48–52; col. 7, ll. 43–45. The '552 patent describes that the second etch is "almost completely anisotropic," which means that the etchant etches in the vertical direction, or perpendicular relative to the substrate surface. *Id.* at col. 7, ll. 45–48; col. 12, ll. 55–58. Hence, the etch removes the etch stop material covering the area of the contact openings or contact regions 460 and 465, but does not significantly etch the etch stop material adjacent to the spacer portions 435.[9] *Id.* at col. 7, ll. 53–55; col. 12, ll. 58–61.

[8] BPTEOS is an acronym for borophosphosilicate tetraethyl orthosilicate glass. *See* Ex. 1001, col. 11, ll. 6–7.

[9] As discussed above, spacer portions 435 are illustrated in Figure 4(D) and the accompanying text. *See* Ex. 1001, col. 11, ll. 40–46, Fig. 4(D).

Figures 4(J) and 4(K) of the ’552 patent are reproduced below.

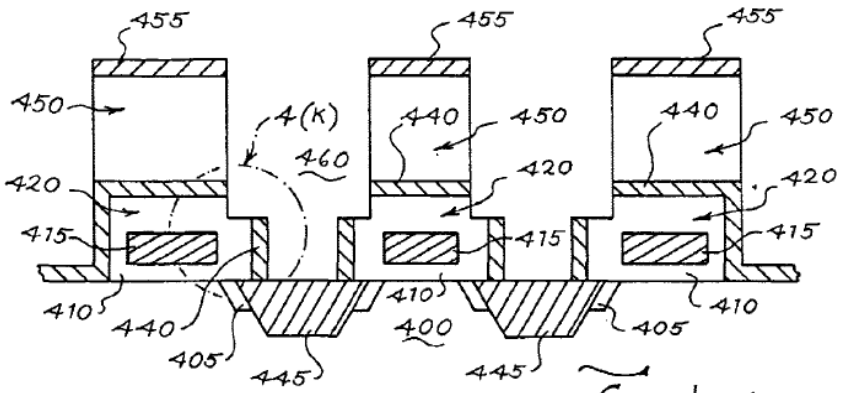


Fig. 4(J)

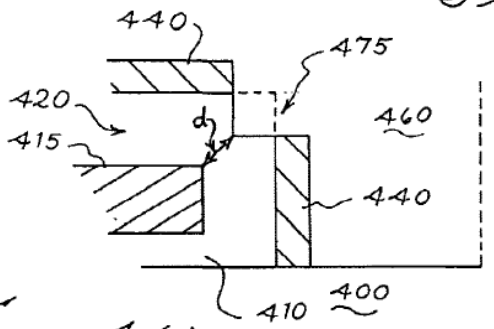


Fig. 4(K)

Figures 4(J) and 4(K) illustrate the structure of the semiconductor device of the ’552 patent after the second etch for removing the etch stop layer from the contact regions 460 and 465 is completed. As shown in Figures 4(J) and 4(K), due to the anisotropic or vertical nature of the second etch, only a small portion, i.e., portion 475, of the TEOS spacer portion 435 is removed during the etch. *Id.* at col. 13, ll. 6–9. Of primary significance, according to the ’552 patent, the spacer portion 435 of the TEOS insulating layer 420 retains its substantially rectangular profile, in contrast to the conventional prior art method which transforms a substantially rectangular spacer into a sloped spacer. *Id.* at col. 13, ll. 9–10; col. 7, ll. 48–51; col. 5, ll. 4–14.

B. Illustrative Claim

Claim 1 is illustrative of the challenged claims and is reproduced below with the key limitation (the "angle limitation") emphasized in *italics*:

> 1. A structure, comprising:
>
> (a) a conductive layer disposed over a substrate;
>
> (b) a first insulating layer on the conductive layer:
>
> (c) a contact region in said first insulating layer;
>
> (d) at least one insulating spacer in the contact region adjacent to the first insulating layer; and
>
> (e) an etch stop material over said first insulating layer and adjacent to the insulating spacer, the etch stop material being a different material from the insulating spacer,
>
> wherein *a side of the insulating spacer has an angle relative to the substrate surface that is either a right angle or an acute angle of more than 85°*.

III. CLAIM CONSTRUCTION

As acknowledged by the parties, the '552 patent has expired. Pet. 29; Prelim. Resp. 15. Thus, we construe the claims in accordance with the standard set forth in *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (en banc). *See In re CSB-Sys. Int'l, Inc.*, 832 F.3d 1335, 1341 (Fed. Cir. 2016) ("[W]hen an expired patent is subject to reexamination, the traditional *Phillips* construction standard attaches.") (citing *In re Rambus*, 694 F.3d 42, 46 (Fed. Cir. 2012)); *Black & Decker, Inc. v. Positec USA, Inc.*, 646 Fed. App'x 1019, 1024 (Fed. Cir. 2016) (holding that in an *inter partes* review, "[c]laims of an expired patent are given their ordinary and customary meaning in accordance with our opinion in [*Phillips*]").

In the Decision on Institution, applying the *Phillips* standard, we preliminarily interpreted the "angle limitation" set forth above—i.e., the limitation reciting "a side of the insulating spacer has an angle relative to the substrate surface that is either a right angle or an acute angle of more than 85°"—to mean "a side of the insulating spacer has an angle relative to the substrate surface that is greater than 85° and less than or equal to 90°." Dec. on Inst. 8–14. Importantly, we were unpersuaded by Patent Owner's argument that the angle of a side of the insulating spacer must be obtained "through the use of a low selectivity etch" (Prelim. Resp. 16–20) and determined that the challenged claims do not require the use of a low selectivity etch. Dec. on Inst. 9–12.

The parties do not present additional claim construction arguments in their Patent Owner Response and Petitioner Reply. Upon considering the complete record, we discern no reason to deviate from our construction, which was adopted from the parties' agreed construction at the district court (Dec. on Inst. at 13–14 (citing Ex. 1028 (Dist. Ct. Claim Construction Order), 7–8)), and maintain our construction of the "angle limitation" to mean "a side of the insulating spacer has an angle relative to the substrate surface that is greater than 85° and less than or equal to 90°."

No other claim terms need to be construed expressly for purposes of this Final Written Decision. *See Wellman, Inc. v. Eastman Chem. Co.*, 642 F.3d 1355, 1361 (Fed. Cir. 2011) (explaining that "claim terms need only be construed 'to the extent necessary to resolve the controversy'" (quoting *Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999))).

IV. ANALYSIS OF PETITIONER'S PRIOR ART CHALLENGES

As previously discussed, the Patent Owner Response does not contain any substantive argument or citations to evidence. Although it remains Petitioner's burden to prove unpatentability by a preponderance of the evidence, in our Scheduling Order, we cautioned Patent Owner that "any arguments for patentability not raised in the response will be deemed waived." *See* Paper 12, 4–5. Patent Owner elected not to respond substantively and, instead, "defers to the Board" to determine whether Petitioner has demonstrated the challenged claims are unpatentable by a preponderance of the evidence. PO Resp. 2. Under the particular circumstance of this case, for purposes of this Final Written Decision, we exercise our discretion to consider Patent Owner's substantive patentability arguments in its Preliminary Response in reaching a decision as set forth below. *See* 37 C.F.R. § 42.5(a).

A. Anticipation by Heath

Petitioner asserts that claims 1, 2, and 4–7 are unpatentable under 35 U.S.C. § 102(b) as anticipated by Heath. Pet. 36–46. Petitioner provides detailed explanations and specific citations to Heath indicating where in the reference the claimed features are disclosed. *Id.* In addition, Petitioner relies upon the Declaration of John C. Bravman, Ph.D. ("Bravman Decl.," Ex. 1002) to support its position. *Id.* Upon review of all of the parties' papers and supporting evidence discussed in those papers, we are persuaded that Petitioner has demonstrated, by a preponderance of evidence, that claims 1, 2, and 4–7 are unpatentable under 35 U.S.C. § 102(b) as anticipated by Heath.

1. Principles of Law

A claim is unpatentable under 35 U.S.C. § 102 only if a single prior art reference expressly or inherently describes each and every limitation set forth in the claim. *See Perricone v. Medicis Pharm. Corp.*, 432 F.3d 1368, 1375 (Fed. Cir. 2005); *Verdegaal Bros., Inc. v. Union Oil Co.*, 814 F.2d 628, 631 (Fed. Cir. 1987). Further, a reference cannot anticipate "unless [it] discloses within the four corners of the document not only all of the limitations claimed[,] but also all of the limitations arranged or combined in the same way as recited in the claim." *Net MoneyIN, Inc. v. VeriSign, Inc.*, 545 F.3d 1359, 1371 (Fed. Cir. 2008). Although the elements must be arranged in the same way as in the claim, "the reference need not satisfy an *ipsissimis verbis* test," i.e., identity of terminology is not required. *In re Gleave*, 560 F.3d 1331, 1334 (Fed. Cir. 2009); *In re Bond*, 910 F.2d 831, 832 (Fed. Cir. 1990). We analyze this asserted ground based on anticipation with the principles identified above in mind.

2. Overview of Heath

Heath describes a process for forming a self-aligned contact window in a semiconductor device, such as an integrated circuit. Ex. 1003, Abstract. Heath describes a two-step etching process which comprises the steps of first etching a dielectric layer down to a silicon nitride etch stop layer, and then etching the etch stop, leaving a "stick" of the etch stop material on the vertical sidewall of the layer to be protected. *Id.*

Figure 8B of Heath is reproduced below.

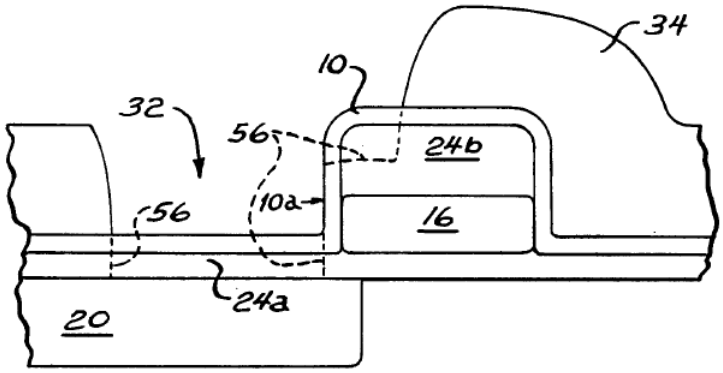


FIG. 8B

Figure 8B depicts a cross-sectional view of a semiconductor structure after the first etching step, including gate electrode 16 insulated from contact window 32 and source or drain 20 by silicon nitride layer 10. *See id.* at col. 9, ll. 50–67. In the second etching step, etch stop layer 10 is removed to open contact window 32 to source or drain 20. Heath describes that, because the nitride removal is anisotropic, vertical "stick" 10a of nitride layer 10 will remain on the side of gate electrode 16 so that no electrical short occurs between the gate electrode and the contact window or the source or drain region. *Id.* at col. 10, ll. 1–11.

3. Discussion

a. Claim 1

Petitioner asserts that the embodiment depicted in Figure 8C of Heath discloses every limitation of claim 1. Pet. 36. According to Petitioner, Heath is directed to the same problem as the '552 patent—i.e., avoiding a short-circuit between the contact and the gate electrode—and describes solving the problem in the same way—that is, through the use of a non-conductive sidewall spacer with vertical sides. *Id.* at 25 (citing Ex. 1003,

Abstract; Ex. 1002 ¶ 60). Petitioner references Figure 8C of Heath and asserts that Heath discloses a transistor structure consisting of the same components arranged in the same way as the invention of the '552 patent. *Id.* at 25–26 (identifying various components depicted in Fig. 8C and citing Ex. 1003, Abstract, Fig. 8C, col. 5, ll. 26–30, col. 10, ll. 2–13; Ex. 1002 ¶¶ 61, 62).

Figure 8C of Heath is reproduced below.

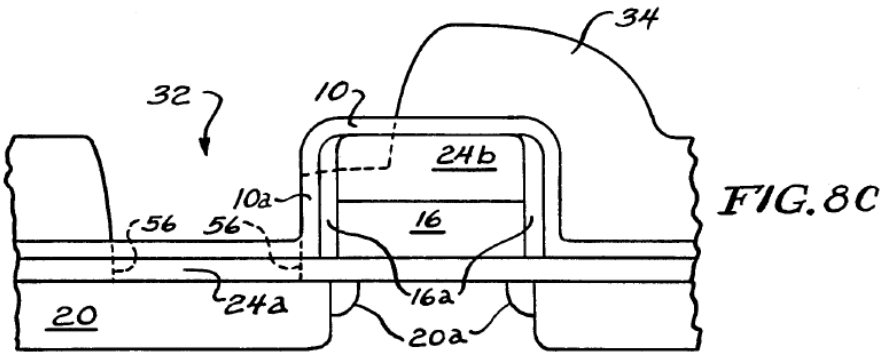


FIG. 8C

Figure 8C above depicts a cross-sectional view of a semiconductor structure at the same stage of processing as Figure 8B (reproduced in Overview of Heath section above) combined with the addition of a sidewall spacer 16a. Ex. 1003, col. 10, ll. 14–19. Referencing Figure 8C, Petitioner provides detailed explanations and specific citations to Heath indicating where in the reference each limitation of claim 1 is disclosed. Pet. 36–43. For the reasons discussed below, we are persuaded that Heath discloses each limitation of independent claim 1 as arranged in the claim.

i. Preamble and Elements (a), (b), (c), (d), and (e)

Beginning with the preamble of claim 1, Petitioner cites Heath's disclosure of a transistor structure in Figure 8C as disclosing a "structure"

recited in claim 1. *Id.* at 36 (citing Ex. 1003, col. 10, ll. 33–35, Fig. 8C; Ex. 1002 ¶ 85). We agree with Petitioner that Figure 8C of Heath discloses a "structure" recited in claim 1 because, as noted by Petitioner, Heath describes methods to "produce a *transistor structure* which has source/drain implants like those shown in FIG. 8C." *Id.* (quoting Ex. 1003, col. 10, ll. 33–35); *see also id.* at 25–26 (Petitioner arguing that Figure 8C of Heath discloses a transistor structure consisting of the same components arranged in the same way as the invention of the '552 patent). As discussed above, both the '552 patent and Heath describe a process of forming a self-aligned contact structure in a semiconductor device. Ex. 1001, Abstract, col. 7, ll. 19–22, col. 8, ll. 4–6 ("The structure contemplated by the invention is an effective device for small feature size structures, particularly self-aligned contacts."); Ex. 1003, Abstract.

Petitioner next addresses the limitations recited in the body of claim 1. Claim 1 numbers from (a) to (e) the elements recited in the body of the claim and recites the numbered elements as follows: (a) a conductive layer disposed over a substrate; (b) a first insulating layer on the conductive layer; (c) a contact region in said first insulating layer; (d) at least one insulating spacer in the contact region adjacent to the first insulating layer; and (e) an etch stop material over said first insulating layer and adjacent to the insulating spacer, the etch stop material being a different material from the insulating spacer.

Petitioner asserts that gate electrode 16 depicted in Figure 8C discloses "(a) a conductive layer disposed over a substrate," as recited in claim 1. *Id.* at 36–37 (citing Ex. 1003, col. 8, ll. 8–11; col. 9, ll. 44–47, 50–

55; col. 7, ll. 36–38; Figs. 2–7, 8C). Petitioner notes that Heath discloses gate electrode 16 is made of polysilicon, which Petitioner argues citing the testimony of Dr. Bravman, a person of ordinary skill in the art would understand to be electrically conductive in a transistor structure. *Id.* at 37 (citing Ex. 1003, col. 8, ll. 8–11; Ex. 1002 ¶ 86). Petitioner further argues that Figure 2 of Heath shows gate electrodes 14 and 16 are formed over substrate 12 as part of the same process of forming the structure depicted in Figure 8C. *Id.* (citing Ex. 1003, col. 7, ll. 36–38, Fig. 2).

We credit Dr. Bravman's testimony and are persuaded that polysilicon used to form gate electrode 16 of Heath is an electrically conductive material. We are also persuaded that Figure 2 of Heath showing gate electrode 16 formed over substrate 12 is part of the same process of forming the structure depicted in Figure 8C because both figures illustrate the process of forming a self-aligned contact window in a semiconductor device. *See* Ex. 1003, col. 2, ll. 28–32 ("FIG. 2 shows an illustrative semiconductor structure near the completion of processing according to the invented process applied illustratively for establishing a *self-aligned contact window* to a gate electrode or field-shield electrode edge." (emphasis added)), col. 11, ll. 11–13 ("As a result of the process described with reference to FIGS. 8 and 9, *the contact window* to the active area will be *self-aligned*, i.e., it will be protected from shorting to an element nearby to which contact is not to be made." (emphases added)). Therefore, we are persuaded by Petitioner's argument and evidence that Heath discloses "(a) a conductive layer disposed over a substrate," as recited in claim 1.

Petitioner next asserts that oxide layer 24b depicted in Figure 8C discloses "(b) a first insulating layer on the conductive layer" recited in claim 1. Pet. 37–38 (citing Ex. 1003, col. 9, ll. 52–55, Fig. 8C). Petitioner relies upon the testimony of Dr. Bravman and argues oxide is a common insulating material known to persons of ordinary skill in the art to be an insulating layer in a transistor structure. *Id.* at 38 (citing Ex. 1002 ¶ 87).

As noted by Petitioner, Figure 8C plainly shows that oxide layer 24b is formed on gate electrode 16. *Id.* 37–38 (identifying oxide layer 24b formed on gate electrode 16 in Petitioner-annotated Fig. 8C (not reproduced herein)). We note that Heath describes oxide as an insulating material. Ex. 1003, col. 5, ll. 27–31 ("a self-aligned contact process which involves establishing gate electrodes . . . protecting the tops of these elements with an *insulating oxide*" (emphasis added)), col. 14, ll. 31–32 ("*Oxide* 87a . . . is grown as an *insulator*" (emphases added)). On the complete record, we credit the testimony of Dr. Bravman and are persuaded that oxide layer 24b on top of gate electrode 16 depicted in Figure 8C discloses "(b) a first insulating layer on the conductive layer," as recited in claim 1.

Figure 8C of Heath, as annotated by Petitioner, is reproduced below.

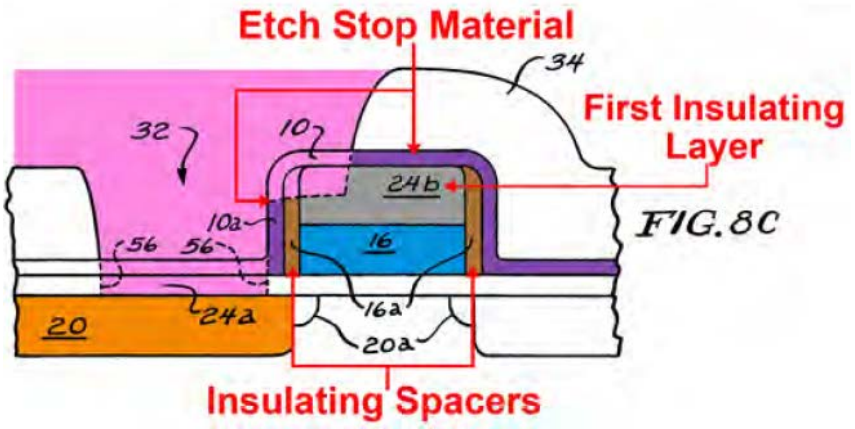


FIG. 8C

Pet. 40. Annotated Figure 8C above shows Petitioner's identification of several limitations of claim 1 present in Heath.

Petitioner asserts that contact window 32 (annotated in pink above) in oxide layer 24b (annotated in gray) shown in Figure 8C discloses "(c) a contact region in said first insulating layer" recited in claim 1. *Id.* at 38–39 (citing Ex. 1003, col. 10, ll. 57–61; Fig. 8C). Citing the testimony of Dr. Bravman, Petitioner argues that contact window 32 (i.e., the claimed "contact region") is created by removing material in insulating layers 24a and 24b (as well as portions of etch stop layer 10 and spacer 16a) in the area colored in pink in Annotated Figure 8C above. *Id.* (citing Ex. 1002 ¶ 88). Petitioner argues that the '552 patent similarly describes the process of forming a contact region in the insulating layer above the gate by etching an opening through the insulating layer. *Id.* at 39 n.8 (citing Ex. 1001, col. 11, ll. 14–17, Fig. 4(B); Ex. 1002 ¶ 88 n.6). Petitioner further argues that contact window 32 forms an opening for electric contact that extends down to source/drain 20. *Id.* at 38 (citing Ex. 1003, col. 10, ll. 57–61; Fig. 8C).

We are persuaded by Petitioner's argument because Figure 8C shows contact window 32 has been formed by creating an opening in oxide layers 24a and 24b, as indicated by the dotted lines 56 outlining the removed portions. Petitioner's argument is consistent with the disclosure in Heath's Figures 8A, 8B, 8C and their accompanying text, which describe in detail the process of forming contact window 32 by etching away materials in oxide layers 24a and 24b (as well as portions of etch stop layer 10 and oxide spacer 16a) along the dotted lines 56 and creating an opening that extends down to source/drain 20. Ex. 1003, Figs. 8A–C, col. 6, l. 67–col. 7, l. 3,

col. 9, l. 50–col. 11, l. 15. Petitioner's cited evidence is part of this disclosure. Based on the complete record, we are persuaded that Heath discloses "(c) a contact region in said first insulating layer," as recited in claim 1.

Petitioner asserts that Figure 8C of Heath also discloses "(d) at least one insulating spacer in the contact region adjacent to the first insulating layer," as recited in claim 1. Pet. 39–40 (citing Ex. 1003, col. 10, ll. 12–27, Fig. 8C). Petitioner identifies sidewall spacer 16a shown in Figure 8C (colored in brown in Annotated Figure 8C reproduced above) as the claimed "insulating spacer," and argues that sidewall spacer 16a is in contact window 32, i.e., the claimed "contact region," and adjacent to oxide layer 24b, the claimed "first insulating layer." *Id.* at 39. Citing the testimony of Dr. Bravman, Petitioner argues that sidewall spacer 16a is an insulating spacer because it is made of insulating oxide. *Id.* at 39–40 (citing Ex. 1003, col. 10, ll. 23–25; Ex. 1002 ¶ 89).

We are persuaded by Petitioner's argument that sidewall spacer 16a is "in" contact window 32 because Figure 8C shows, as indicated by dotted line 56, a portion of sidewall spacer 16a has been removed to create an opening and form contact window 32. We are also persuaded that oxide spacer 16a is an insulating spacer because, as discussed above, oxide is a common insulating material known to persons of ordinary skill in the art. Therefore, we are persuaded that Heath discloses "(d) at least one insulating spacer in the contact region adjacent to the first insulating layer," as recited in claim 1.

Referencing Annotated Figure 8C reproduced above, Petitioner next asserts that Heath discloses "(e) an etch stop material over said first insulating layer and adjacent to the insulating spacer, the etch stop material being a different material from the insulating spacer," as recited in claim 1. Pet. 40–41 (citing Ex. 1003, Abstract, col. 5, ll. 38–39, col. 9, ll. 2–4, 66–67, col. 10, ll. 12–27, Fig. 8C). Petitioner identifies etch stop layer 10 shown in Figure 8C (annotated in purple in Annotated Figure 8C above) as the claimed "etch stop material" and argues that, as shown in Figure 8C, etch stop layer 10 is over oxide layer 24b (i.e., the claimed "first insulating layer") and adjacent to sidewall spacer 16a (i.e., the claimed "insulating spacer"). *Id.* at 40. Citing the testimony of Dr. Bravman, Petitioner asserts that etch stop layer 10 is a "different material" from sidewall spacer 16a because etch stop layer 10 made of silicon nitride whereas sidewall spacer 16a is formed of oxide. *Id.* (citing Ex. 1003, Abstract, col. 5, ll. 38–39, col. 9, ll. 2–4, 66–67, col. 10, ll. 12–27; Ex. 1002 ¶ 90). Petitioner further argues that, in both the '552 patent and Heath, a vertical "stick" of etch stop material remains adjacent to the sidewall spacer in the contact opening after the etching process forms the contact opening. *Id.* at 40–41 (citing Ex. 1001, col. 12, ll. 58–65; Ex. 1003, col. 10, ll. 1–11; Ex. 1002 ¶ 91).

We are persuaded by Petitioner's argument because Figure 8C plainly shows etch stop layer 10 is over oxide layer 24b and adjacent to sidewall spacer 16a on the right side of oxide layer 24b. As noted by Petitioner, sidewall spacer 16a is also adjacent to "vertical 'stick' 10a of layer 10" on the left side of oxide layer 24b, as illustrated in Figure 8C. *Id.* (quoting Ex. 1003, col. 10, ll. 1–11). In addition, we credit Dr. Bravman's testimony

and are persuaded that silicon nitride which comprises etch stop layer 10 is a different material from oxide that makes up sidewall spacer 16a. Therefore, we are persuaded that Heath discloses "(e) an etch stop material over said first insulating layer and adjacent to the insulating spacer, the etch stop material being a different material from the insulating spacer," as recited in claim 1.

Patent Owner does not dispute specifically Petitioner's contention that Heath discloses the preamble and numbered elements (a), (b), (c), (d), and (e) of claim 1. Upon considering the complete record, we determine Petitioner has demonstrated that Heath discloses the preamble and elements (a), (b), (c), (d), and (e) of claim 1.

ii. The "Angle Limitation"

The last limitation of claim 1, the "angle limitation," recites "wherein a side of the insulating spacer has an angle relative to the substrate surface that is either a right angle or an acute angle of more than 85°." Petitioner asserts that Figure 8C of Heath also discloses the "angle limitation" recited in claim 1. Pet. 41–43. According to Petitioner, Heath discloses a sidewall spacer 16a with a side that is at a right angle relative to the substrate surface because Heath describes the sidewall spacers as "vertical" with respect to the substrate. *Id*. at 41–42 (citing Ex. 1003, Abstract; col. 11, ll. 1–10; Fig. 8C). Pointing to Figure 8C of Heath, Petitioner argues Heath describes that the entire side of the sidewall spacer is at a 90° angle relative to the substrate surface, and, therefore, the sidewall spacer meets the "angle limitation" regardless of where along the side of the sidewall spacer—be it near the

bottom or near the top of the spacer—the angle is measured relative to the substrate surface. *Id.* at 42–43.

Patent Owner asserts that Heath does not disclose the "angle limitation" recited in claim 1 because Heath does not describe using a low selectivity etch to obtain substantially rectangular insulating spacers. Prelim. Resp. 26–27. Patent Owner further asserts that Heath is merely cumulative of the prior art structure disclosed in the Background of the Invention section of the '552 patent and that the vertical sidewall in Figure 8C of Heath relied upon by Petitioner is the same as the prior art "vertical sidewall" that is shown in Figure 1(B) of the '552 patent. *Id.* at 27–28. Patent Owner contends that both figures do not show actual etching effects and that Heath's use of a selective etch process will result in a final structure with a sloped spacer, not a spacer with a substantially rectangular profile required by claim 1. *Id.* at 27–29. According to Patent Owner, the '552 patent improves upon the vertical sidewall spacers present in the background prior art discussed in the '552 patent in that the claimed invention uses a low selectivity etch instead of a selective etch process. *See id.* at 29.

Patent Owner's "low selectivity etch" argument primarily turns on the claim construction of the "angle limitation" and is, therefore, unpersuasive because we do not agree with Patent Owner's proposed construction of the term requiring the use of a low selectivity etch. As discussed in Section III.A. (Claim Construction) above, we determine neither the "angle limitation" nor any other term in the challenged claims requires the use of a low selectivity etch for the reasons explained in our Decision on Institution. Dec. on Inst. 8–12.

With respect to Patent Owner's argument based on the prior art structure described in the Background of the Invention section of the '552 patent, we are not persuaded vertical sidewall spacers are present in Figure 1(B) of the '552 patent because, other than pointing to Figure 1(B), Patent Owner provides no further explanation or supporting evidence to show why the dielectric spacer 150 depicted in Figure 1(B) has a vertical sidewall relative to the substrate surface. Nor do we discern any disclosure in the '552 patent that describes an insulating spacer depicted in Figure 1(B) as having a vertical sidewall. Rather, the '552 patent describes in detail that the prior art process of forming contact regions transforms a substantially rectangular spacer into a sloped spacer. *See* Ex. 1001, col. 4, l. 26–col. 6, l. 12; Figs. 2(A), 2(B), 3. Patent Owner provides no explanation or supporting evidence why the illustration in Figure 1(B) departs from this description and, instead, discloses insulating spacers with a vertical sidewall relative to the substrate surface.

In addition, although Figure 1(B) of the '552 patent may not show actual etching effects because sloped spacers are shown in more detailed illustration of prior art structures depicted in Figures 2(B) and 3, we are not persuaded that Figure 8C of Heath does not show actual etching effects or that Heath's use of a selective etch process will result in a final structure with a sloped spacer. According to Petitioner, Heath describes, contrary to Patent Owner's contention, etching "anisotropic[ally]" in a vertical direction to maintain the vertical sidewalls of the lateral spacer. Pet. 26 (quoting Ex. 1003, col. 10, ll. 2–11 ("[T]he part of layer 10 between dashed lines 56 is removed leaving a *vertical stick 10a* of layer 10 . . . . Some oxide 24 will

remain on the top of gate electrode 16 even after the etch exposes the source/drain region 20 within the contact window, and *because the nitride removal is anisotropic* [i.e., it can etch vertically], *the 'stick' 10a will remain on the side, so no short to electrode 16 can occur*.")) (citing Ex. 1003, Abstract; Ex. 1002 ¶ 62). As shown in Figure 8C, because the *vertical* "stick" 10a remains on the sidewall of the insulating spacer 16a after the anisotropic etching of the etch stop layer 10, the insulating spacer has a vertical side relative to the substrate surface. Thus, Petitioner has shown that Heath describes an anisotropic etching process for the etch stop layer that results in insulating spacers with a side that has a vertical profile or is at a right angle relative to the substrate surface.

As discussed in Section III.A. above, we construe the "angle limitation" to mean "a side of the insulating spacer has an angle relative to the substrate surface that is greater than 85° and less than or equal to 90°." We are persuaded that Heath discloses the "angle limitation" under this construction because the vertical side of oxide spacer 16a "has an angle relative to the substrate surface that is greater than 85° and less than or equal to 90°," as recited in claim 1.

iii. Conclusion

Therefore, based on the complete record, we find that Petitioner has shown Heath discloses each limitation of independent claim 1 as arranged in the claim. Accordingly, upon considering all of the evidence of record, we determine that Petitioner has demonstrated, by a preponderance of evidence,

that claim 1 is unpatentable under 35 U.S.C. § 102(b) as anticipated by Heath.

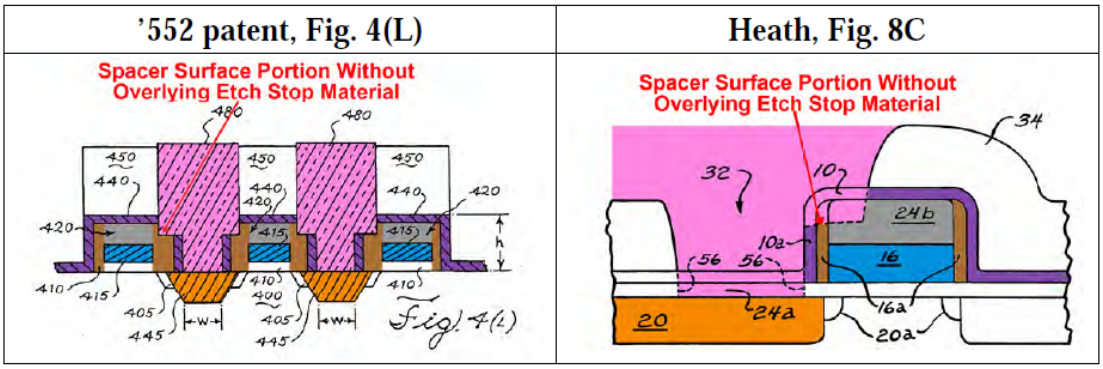
b. Dependent Claims 2 and 4–7

For claims 2 and 4–7, which depend directly or indirectly from claim 1, Petitioner provides detailed explanations and specific citations to Heath indicating where in the reference the additionally recited limitations of the dependent claims are disclosed. Pet. 43–46.

With respect to claim 2, which depends from claim 1 and further recites "said etch stop material comprises silicon nitride," Petitioner asserts that the '552 patent teaches silicon nitride etch stop layers were well-known in the prior art. *Id.* at 43 (citing Ex. 1001, col. 4, ll. 42–44; Fig. 2; Ex. 1002 ¶ 95). Petitioner asserts that Heath also discloses using a silicon nitride etch stop material. *Id.* (citing Ex. 1003, col. 5, ll. 38–39; col. 9, ll. 66–67; Abstract). We are persuaded that Heath discloses "said etch stop material comprises silicon nitride," as recited in claim 2, because, as noted by Petitioner, Heath discloses "[t]he etch stop preferably is *silicon nitride*." *Id.* (quoting Ex. 1003, col. 5, ll. 38–39).

Claim 4 depends from claim 1 and further recites "the insulating spacer has a surface portion in the contact region without overlying etch stop material." Comparing Figure 8C of Heath to Figure 4(L) of the '552 patent, Petitioner asserts that Heath discloses sidewall spacer 16a (i.e., the claimed "insulating spacer") that has a surface portion in contact window 32 (i.e., the claimed "contact region") that is not covered by etch stop layer 10 (i.e., the claimed "etch stop material"), similar to the insulating spacer described in

Figure 4(L) of the ’552 patent. Pet. 44. The figure below is Petitioner’s comparison of Figure 4(L) of the ’552 patent on the left and Figure 8C of Heath on the right.



Petitioner’s Comparison of
Fig. 4(L) of the ’552 Patent to Fig. 8C of Heath

Id. Petitioner argues that the portion of the sidewall spacer 16a indicated by the red arrow in Petitioner-annotated Figure 8C above does not have etch stop material overlaying it because that portion of the etch stop layer 10 has been removed via the etching process in order to create contact window 32. *Id.* (citing Ex. 1003, col. 10, ll. 1–3; Ex. 1002 ¶ 96). Hence, Petitioner asserts that Heath discloses “the insulating spacer has a surface portion in the contact region without overlying etch stop material,” as recited in claim 4. *Id.* at 43–44.

Claim 5 depends from claim 4 and additionally recites “the insulating spacer surface portion without overlying etch stop material comprises an insulating spacer surface portion most distant from said substrate.” Petitioner presents another comparison of Figure 8C of Heath and Figure 4(L) of the ’552 patent (not reproduced herein) and argues that the surface

portion of sidewall spacer 16a identified in connection with Petitioner's discussion of claim 4 above is the portion of the oxide spacer that is farthest away or most distant from the substrate surface, similar to the structure described in Figure 4(L) of the '552 patent. *Id.* at 44–45 (citing Ex. 1002 ¶ 97). Thus, Petitioner asserts that Heath discloses "the insulating spacer surface portion without overlying etch stop material comprises an insulating spacer surface portion most distant from said substrate," as recited in claim 5. *Id.* at 44–45.

Based on the foregoing and upon reviewing Figure 8C and the structures or geometries evidently shown in the figure, we are persuaded that Petitioner has cited sufficient disclosure from Heath to show Heath discloses the limitations recited in claims 4 and 5.

Claim 6 depends from claim 1 and recites "further comprising a second insulating layer on the etch stop layer and over the conductive layer." Petitioner presents another annotated Figure 8C (not reproduced herein) and identifies dielectric layer 34 (annotated in green) as the claimed "second insulating layer." Pet. 45–46. Petitioner argues that, as shown in Figure 8C, dielectric layer 34 is formed by depositing borophosphosilicate glass ("BPSG") on etch stop layer 10 and over gate electrode 16 (i.e., the claimed "conductive layer"). *Id.* (citing Ex. 1003, col. 7, ll. 48–50, Fig. 8C). Citing the testimony of Dr. Bravman, Petitioner argues that BPSG is an insulator. *Id.* (citing Ex. 1002 ¶ 98). Hence, Petitioner asserts that Heath discloses "a second insulating layer on the etch stop layer and over the conductive layer," as recited in claim 6.

Upon reviewing Figure 8C and the structures or geometries evidently shown in the figure, we credit Dr. Bravman's testimony and are persuaded that Heath discloses a second insulating layer on the etch stop layer and over the conductive layer," as recited in claim 6.

Claim 7 depends from claim 6 and additionally recites "further comprising a second conductive material in the contact region." Petitioner contends that this claimed "second conductive material in the contact region" refers to the electrically conductive material that is placed into the contact region, thus forming the contact, as shown in Figure 4(L) of the '552 patent. Pet. 46 (citing Ex. 1001, col. 13, ll. 43–45; Fig. 4(L)). Petitioner asserts that Heath discloses "a second conductive material in the contact region," as recited in claim 7, because Heath describes that contact window 32 can be filled with metal to form a contact. *Id.* (citing Ex. 1003, col. 11, ll. 50–51; col. 12, ll. 8–9, 42–43; Ex. 1002 ¶ 99).

Figure 4(L) of the '552 patent is reproduced below.

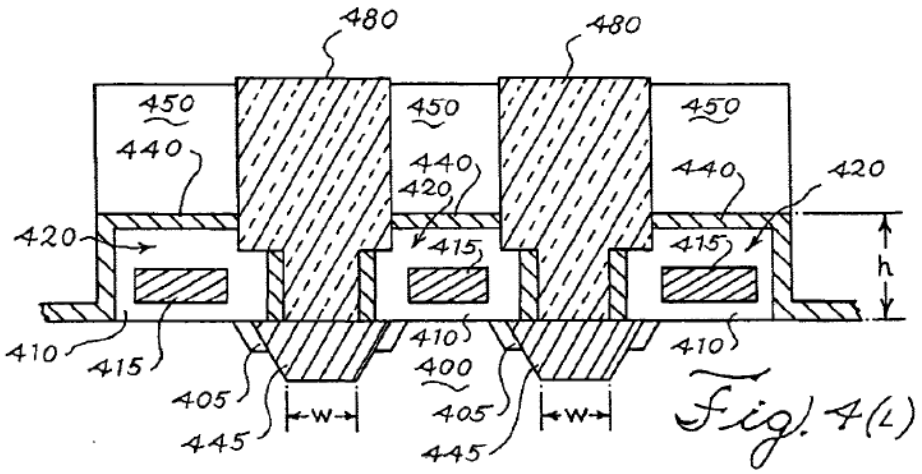


Figure 4(L) illustrates the structure of the semiconductor device of the '552 patent after conductive contacts 480 have been deposited in contact openings

460. Ex. 1001, col. 13, ll. 43–45. The '552 patent describes that, once contact openings are formed by the process of fabrication depicted in Figures 4(A) to 4(K), the only material deposited in the contact openings is conductive contacts. *See id.* at col. 13, l. 43–col. 14, l. 9. Furthermore, the '552 patent describes providing high quality contacts between a conductive material in the contact region and a device region, such as source or drain 445, as one of the primary goals of the described invention. *See id.* at col. 7, ll. 20–23 (SUMMARY OF THE INVENTION), Abstract. In view of these disclosures in the Specification, we are persuaded that "a second conductive material in the contact region" recited in claim 7 encompasses electrically conductive material that is placed into the contact region to form a contact. Hence, we agree with Petitioner that Heath's contact window 32 filled with metal to form a contact constitutes "a second conductive material in the contact region" recited in claim 7.

Patent Owner does not respond separately, with specificity, to Petitioner's challenge to dependent claims 2 and 4–7 beyond Patent Owner's arguments advanced with respect to claim 1 discussed above. Upon considering the complete record, we determine that Petitioner has demonstrated, by a preponderance of evidence, that claims 2 and 4–7 are unpatentable under 35 U.S.C. § 102(b) as anticipated by Heath.

B. Obviousness Based on the Combination of Heath, Hawley, and Chappell

Claim 3 depends from claim 1 and further recites "said etch stop material comprises silicon dioxide." Petitioner asserts that claim 3 is unpatentable under 35 U.S.C. § 103(a) over the combination of Heath,

Hawley (Ex. 1004), and Chappell (Ex. 1005). Pet. 47–50. According to Petitioner, Heath teaches that materials other than silicon nitride can be used as etch stop materials. *Id.* at 47 (citing Ex. 1003, col. 6, ll. 18–25). Petitioner further asserts that Hawley—which, like the '552 patent and Heath, is directed to the use of etch stop layers in the fabrication of layered structures in semiconductor devices—specifically teaches using silicon dioxide as an etch stop layer. *Id.* at 47–48 (quoting Ex. 1004, col. 2, ll. 43–44 ("*The second etch-stop dielectric layer*, if used, *may comprise a thin layer of silicon dioxide*."). Hence, Petitioner asserts that a person of ordinary skill in the art would have known that the silicon nitride etch stop layer in Heath can be replaced with silicon dioxide, as taught by Hawley. *Id.* at 48 (citing Ex. 1002 ¶ 102).

Petitioner acknowledges that, because claim 3 depends from claim 1—which requires the etch stop material to be "different material" than the insulating spacer—the insulating spacer must also be a material different from silicon dioxide, e.g., silicon nitride, to satisfy claim 3. *Id.* Citing Chappell, Petitioner asserts that using different materials than oxide for sidewall spacers was well-known in the art at the time of the invention of the '552 patent. *Id.* According to Petitioner, Chappell, like Heath, Hawley, and the '552 patent, is directed to the fabrication of contact openings to diffusion regions. *Id.* Referencing Figures 2 and 5 of Chappell, Petitioner asserts that Chappell teaches spacers can be formed of nitride because Chappell discloses nitride spacers formed next to a gate stack and contact opening. *Id.* (quoting Ex. 1005, col. 4, ll. 7–8 ("*Nitride spacers 28 are formed along the gate edges.*")) (citing Ex. 1005, Figs. 2, 5). Petitioner asserts, therefore,

a combination of Heath, Hawley, and Chappell teaches all of the limitations of claim 3, including all of the limitations of base claim 1. *Id.* at 48–49.

Relying upon the testimony of Dr. Bravman, Petitioner also contends that a person of ordinary skill in the art would have been motivated to combine Heath, Hawley, and Chappell because all three references relate to the same technique (the formation of contact openings in transistor structures) in the same field (transistor fabrication and design). *Id.* at 49 (citing Ex. 1002 ¶ 104; Ex. 1003, Abstract; Ex. 1004, Abstract, col. 4, ll. 16–18; Ex. 1005, col. 2, ll. 16–18). Petitioner further asserts that a person of ordinary skill in the art would have been motivated to combine Heath, Hawley, and Chappell to make an insulating spacer formed of nitride and an etch stop material made of silicon dioxide because the choice of materials for spacers and etch stop layers was a simple design choice for one of ordinary skill in the art. *Id.* (citing Ex. 1002 ¶ 105). Petitioner argues that the '552 patent itself recognizes that it would "be *appreciated by those of ordinary skill in the art* that this silicon nitride layer 440 [i.e., the claimed etch stop material] could instead be an insulating layer of, for example, *silicon dioxide*, SiO_2, ONO, or $SiO_xN_y(H_z)$." *Id.* (citing Ex. 1001, col. 11, l. 66–col. 12, l. 2; Ex. 1002 ¶ 105).

Upon reviewing Petitioner's argument and evidence, we are persuaded that the proposed combination of Heath, Hawley, and Chappell teaches an insulating spacer formed of nitride and an etch stop material made of silicon dioxide. We also agree with Petitioner that Heath, Hawley, and Chappell all are directed to the same or similar technology of forming contact openings in transistor structures in the same field of semiconductor

fabrication and design. We note that all three references describe a process of forming contact openings by etching a multi-layer structure. Ex. 1003, Abstract, Fig. 8C; Ex. 1004, Abstract, col. 2, ll. 39–44; Ex. 1005, col. 2, ll. 16–18, col. 4, ll. 7–8, Figs. 2, 5. As discussed above, the '552 patent is also directed to a process of forming contact openings in semiconductor devices by etching a multi-layer structure. *See* Ex. 1001, Figs. 4(A)–4(L). Hence, we are persuaded that a person of ordinary skill in the art would have been motivated to look to the teachings of Heath, Hawley, and Chappell when considering the materials to use for insulating layers and etch stop layers in the process of making contact openings in a multi-layer structure of a semiconductor device, such as the "self-aligned" contacts described in the '552 patent and Heath. *See KSR Int'l Co. v. Teleflex Inc*., 550 U.S. 398, 420 (2007) ("any need or problem known in the field and addressed by the patent can provide a reason for combining the elements in the manner claimed").

We are also persuaded by Petitioner's argument that a person of ordinary skill in the art would have understood the interchangeable use of silicon dioxide and silicon nitride for the etch stop layer and the insulating spacer as a matter of simple design choice because the '552 patent expressly contemplates the interchangeable use of silicon dioxide and silicon nitride for the etch stop layer. Based on the complete record, we credit the testimony of Dr. Bravman and are persuaded that it would have been obvious to a person of ordinary skill in the art to combine Heath, Hawley, and Chappell to make a structure recited in claim 3, including an "etch stop material" comprising silicon dioxide and an "insulating spacer" made of a different material from the etch stop material, such as silicon dioxide. *See*

KSR, 550 U.S. at 416 (when a patent claims a structure already known in the prior art that is altered by mere substitution of one element for another known in the field, the result is likely to be obvious if the combination does no more than yield predictable results).

Patent Owner does not respond separately, with specificity, to Petitioner's challenge to claim 3 beyond Patent Owner's arguments advanced with respect to claim 1 discussed above. *See* Prelim. Resp. 29–30. Upon considering the complete record, we determine that Petitioner has demonstrated, by a preponderance of evidence, that the subject matter of claim 3 would have been obvious under 35 U.S.C. § 103(a) based on the combination of Heath, Hawley, and Chappell.

V. CONCLUSION

Petitioner has met its burden of proof, by a preponderance of the evidence, in showing that claims 1, 2, and 4–7 of the '552 patent are unpatentable under 35 U.S.C. § 102(b) as anticipated by Heath and that claim 3 is unpatentable under 35 U.S.C. § 103(a) as obvious over the combination of Heath, Hawley, and Chappell.

VI. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that claims 1–7 of the '552 patent are *unpatentable*; and

FURTHER ORDERED that, because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

PETITIONER:

Grant K. Rowan
Yung-Hoon Ha
Wilmer Cutler Pickering Hale and Door LLP

grant.rowan@wilmerhale.com
yung-hoon.ha@wilmerhale.com

PATENT OWNER:

Andriy Lytvyn
Anton J. Hopen
Nicholas Pfeifer Smith & Hopen, P.A.

andriy.lytvyn@smithhopen.com
anton.hopen@smithhopen.com
nicholas.pfeifer@smithhopen.com