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Paper No. 59
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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MICRON TECHNOLOGY, INC.
Petitioner

v.

THE BOARD OF TRUSTEES OF THE UNIVERSITY OF ILLINOIS
Patent Owner

Case IPR2013-00008
Patent 5,872,387

Before SALLY GARDNER LANE, BRYAN F. MOORE, and MICHAEL J. FITZPATRICK, *Administrative Patent Judges.*

FITZPATRICK, *Administrative Patent Judge.*

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

BACKGROUND

Micron Technology, Inc. (“Micron”) filed a Petition (Paper 2, “Pet.”) requesting an *inter partes* review of all claims (i.e., claims 1 and 2) of U.S. Patent No. 5,872,387 (the “’387 patent”). The Board of Trustees of the University of Illinois (“the University”) filed a Patent Owner Preliminary Response (Paper 16, “Prelim. Resp.”). In a March 13, 2013, Decision to Institute (Paper 24, “Dec. on Pet.”), the Board granted the Petition and instituted trial of both claims on the following grounds:

claims 1 and 2 as obvious over Lisenker (Ex. 1006)[1] and Hwang (Ex. 1004)[2];

claims 1 and 2 as obvious over Lisenker in view of Hwang and Deal (Ex. 1008)[3]; and

claims 1 and 2 as obvious over Deal in view of Hwang and Lisenker.

Dec. on Pet. 16.

After institution, the University filed a Patent Owner Response (Paper 33, “PO Resp.”). In it, the University opposes the grounds of unpatentability on two general bases: (1) the Board’s findings, in instituting trial, regarding Lisenker are incorrect; and (2) objective indicia prove the claims would not have been obvious. Micron filed a Reply (Paper 36). Oral hearing was held on December 9, 2013.[4]

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[1] WO 94/19829 to Lisenker et al. (Sep. 1, 1994).

[2] HWANG ET AL., *Improved Reliability Characteristics of Submicrometer nMOSFET’s with Oxynitride Gate Dielectric Prepared by Rapid Thermal Oxidation in N_2O*, IEEE ELECTRON DEVICE LETTERS, Vol. 12, No. 9, 495-497 (Sep. 1991).

[3] US 4,027,380 to Deal et al. (June 7, 1977).

[4] A transcript of the final hearing is included in the record.

The Board has jurisdiction under 35 U.S.C. § 6(c). This final written Decision, issued pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73, addresses issues and arguments raised during the trial. Issues and arguments raised prior to institution of trial, but not made during trial, are not addressed necessarily in this Decision.

As discussed below, Micron has shown by a preponderance of the evidence that claims 1 and 2 of the ’387 patent are unpatentable.

A. Related Proceedings

Micron indicates that it is a named defendant in a pending district court case concerning the ’387 Patent brought by the University and captioned *The Board of Trustees of the University of Illinois v. Micron Technology, Inc.*, Case No. 2:11-cv-02288 (C.D. Ill.). Pet. 1.

Also, Micron filed two additional petitions, which we granted, for *inter partes* reviews of two related patents: IPR2013-00005, regarding U.S. Patent No. 6,444,533 B1, and IPR2013-00006, regarding U.S. Patent No. 6,888,204 B1.

B. The ’387 Patent (Ex. 1002)

The ’387 patent, titled “Deuterium-Treated Semiconductor Devices,” is assigned to the University. Ex. 1002, 1. The ’387 patent issued from U.S. Application Serial No. 08/586,411, filed January 16, 1996. *Id.*

The ’387 patent “relates to methods for treating semiconductor devices or components thereof in order to reduce the degradation of semiconductor device characteristics over time.” Ex. 1002, col. 1, ll. 6-9. In particular, the ’387 patent discloses methods of treating a semiconductor device by passivation of (or annealing[5]) the device with deuterium, an isotope of hydrogen. Ex. 1002, col. 2, ll. 19-22; Prelim. Resp. 1. The ’387 patent explains:

> [T]reatment with deuterium provides a reduction in the depassivation or “aging” of semiconductor devices due to hot-carrier effects. Such aging is evidenced, for example, by substantial degradations of threshold voltage, transconductance, or other device characteristics. In accordance with the present invention, semiconductor devices are fabricated using deuterium to condition the devices and stably reduce the extent of these degradations.

Ex. 1002, col. 3, ll. 23-31.

Prior to the ’387 patent, passivation with hydrogen[6] was “a well-known and established practice in the fabrication of semiconductor devices” to remove defects that affect the operation of the devices. Ex. 1002, col. 1, ll. 10-14; Ex. 1001 (Reed Decl.) ¶¶ 13-14. According to the ’387 Patent, it was “discovered that semiconductor devices, for example including MOS[7] devices, can be advantageously treated with deuterium to improve their operational characteristics.” Ex. 1002, col. 2, ll. 16-19.

C. The Claims

There are only two claims in the ’387 patent, both of which are independent. They read as follows:

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[5] Micron’s witness testified that passivation is also referred to as annealing. Ex. 1001 (declaration of Michael L. Reed, Ph.D. (“Reed Decl.”)) ¶ 14.

[6] Our use of the term “hydrogen” and the symbol “H” in this Decision refers to naturally occurring hydrogen, which we understand to be predominantly protium, but may include trace amounts of deuterium.

[7] MOS refers to metal oxide semiconductor. Ex. 1002, col. 1, ll. 28-29; Ex. 1001 (Reed Decl.) ¶ 9.)

> 1. A field effect transistor having an interface between a semiconductive silicon layer and a gate oxide layer comprising silicon oxy nitride, characterized by post-fabrication passivation of said interface in a heated, deuterium gas-enriched atmosphere so as to increase the resilience of the field effect transistor to hot electron effects.
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> 2. A field effect transistor having an interface between a silicon semiconductive layer and a gate oxide layer comprising silicon oxy nitride, said transistor being passivated by covalently bound deuterium atoms at said interface and thereby having an increased resilience to hot carrier effects, said field effect transistor being characterized by post-fabrication passivation for at least one hour in a deuterium gas-enriched atmosphere heated to a temperature of at least 200º C., and wherein said post-fabrication passivation is conducted sufficiently to provide to said transistor a practical lifetime at least about ten times that provided by a corresponding passivation with hydrogen gas, wherein practical lifetime is taken as 20% transconductance degradation as a result of electrical stress.

Ex. 1002, col. 8, ll. 16-36.

ANALYSIS

A. Claim Construction

In an *inter partes* review, "[a] claim in an unexpired patent shall be given its broadest reasonable construction in light of the specification of the patent in which it appears." 37 C.F.R. § 42.100(b). That construction must be consistent with the specification, and the claim language should be read in light of the specification as it would be interpreted by one of ordinary skill in the art. *In re Suitco Surface, Inc.*, 603 F.3d 1255, 1260 (Fed. Cir. 2010). Thus, we give claim terms their ordinary and customary meaning. *See In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007) ("The ordinary and customary meaning is the meaning that the term would have to a person of ordinary skill in the art in question.") (internal quotation marks omitted).

In instituting trial, we gave each claim term its broadest reasonable interpretation, as understood by one of ordinary skill in the art and consistent with the disclosure of the '387 patent, as neither party had argued persuasively that any claim or term should be construed otherwise. However, Micron did point out that the claims should be interpreted as product-by-process claims. Pet. 11. We agree, as discussed below.

1. Claim 1

Independent claim 1 is in product-by-process format, claiming a field effect transistor that, among other things, is made by a certain process, namely "post-fabrication passivation of said interface in a heated, deuterium gas-enriched atmosphere so as to increase the resilience of the field effect transistor to hot electron effects."

"[E]ven though product-by-process claims are limited by and defined by the process, determination of patentability is based on the product itself." *In re Thorpe*, 777 F.2d 695, 697 (Fed. Cir. 1985). Thus, for patentability purposes, we look to the product claimed, not the process by which it is made. *See id*. ("If the product in a product-by-process claim is the same as or obvious from a product of the prior art, the claim is unpatentable even though the prior product was made by a difference process."); *Amgen Inc. v. F. Hoffman-La Roche Ltd.*, 580 F.3d 1340, 1366 (Fed. Cir. 2009) ("It has long been the case that an old product is not patentable even if it is made by a new process.") (citing *General Elec. Co. v. Wabash Appliance Corp.*, 304 U.S. 364, 373 (1938)).

Claim 1 requires deuterium at the interface. A reference teaching deuterium at the interface would meet this requirement even if formed by a process different than that which is claimed, unless evidence is put forth establishing an unobvious difference between the claimed product and the prior art product. *See In re Marosi*, 710 F.2d 799, 803 (Fed. Cir. 1983).

The University maintains that the specific process recited by claim 1 (post-fabrication passivation in a heated, deuterium gas enriched atmosphere) is required by the claim under an exception to the product-by-process rule. PO Resp. 17 (citing *Greenliant Sys., Inc. v. Xicor LLC*, 692 F.3d 1261, 1268 (Fed. Cir. 2012)). In *Greenliant*, the court held:

> [T]here is an exception to this general rule that the process by which the product is made is irrelevant. . . . [I]f the process by which a product is made imparts structural and functional differences distinguishing the claimed product from the prior art, then those differences are relevant as evidence of no anticipation although they are not explicitly part of the claim.

Greenliant, 692 F.3d at 1268 (quotation marks omitted). The University alleges that the process recited in claim 1 imparts a structural and functional difference resulting in a lifetime extension of the semi-conductor device of between 10 and 50 times. PO Resp. 18. In support, the University refers to "experimental data included in the specification of the '387 patent" but does not provide a citation. *Id*. In fact, the experimental data in the Specification does not link lifetime extension to *post-fabrication* passivation with deuterium. Rather, it links lifetime extension to deuterium passivation in general (i.e., as opposed to the prior art method of using hydrogen). *See* Ex. 1002, Figs. 2 and 3; col. 5, ll. 44-49 ("[D]ramatic decreases in the degradation of threshold voltage and transconductance are observed when deuterium is used to passivate the devices, as compared to hydrogen passivation (see FIGS. 2 and 3, respectively). These decreases represent practical lifetime improvements by factors of about ten to fifty . . . ."); col. 7, l. 38 – col. 8, l. 2 ("[T]ransistors sintered in deuterium typically exhibit lifetimes 10 times longer than those sintered in hydrogen.").

Although claim 1 requires retention of deuterium at the interface so as to increase the resilience of the field effect transistor to hot electron effects, it does not require any specific process that results in deuterium at the interface.

2. Claim 2

Independent claim 2 also is in product-by-process format, claiming a field effect transistor that, among other things, is made by a certain process, namely "post-fabrication passivation for at least one hour in a deuterium gas-enriched atmosphere heated to a temperature of at least 200º C., and wherein said post-fabrication passivation is conducted sufficiently to provide to said transistor a practical lifetime at least about ten times that provided by a corresponding passivation with hydrogen gas, wherein practical lifetime is taken as 20% transconductance degradation as a result of electrical stress."

For patentability purposes, we do not give weight to the recited process that results in deuterium at the interface. *See Thorpe*, 777 F.2d at 697; *Amgen*, 580 F.3d at 1366. Claim 2 requires deuterium at the interface, but it does not require any specific process that results in deuterium at the interface.

B. Prior Art References In Trial

1. Lisenker (Ex. 1006)

Lisenker discloses "a method for producing semiconductor devices in which hydrogen-containing bonds in silicon dioxide are replaced with deuterium containing bonds. Specifically Si-H bonds are replaced with Si-D bonds and Si-OH bonds are replaced with Si-OD bonds." Ex. 1006, 5, l. 36 – 6, l. 3. Lisenker further discloses how the method may be carried out, stating:

> a silicon wafer is contacted with a deuterium containing material to form Si-D and Si-OD bonds in a silicon dioxide layer and on a silicon surface at an interface with the silicon dioxide layer. Typical silicon dioxide layers suitable for treatment according to the present invention include isolation oxides, gate oxides, and various other oxide layers commonly used with semiconductor devices. According to the invention, deuterium or a deuterium-containing material is directed onto the device by, for example, annealing in a deuterium containing atmosphere, and/or cleaning with a deuterium compound such as D_2O, D_2SO_4, and DCl. In general, any hydrogen containing material used in VLSI[8] fabrication can be replaced with corresponding deuterium containing material.

Ex. 1006, 4, ll. 20-34.

Finally, Lisenker discloses the benefits of the method and how those benefits are obtained, stating:

> The stability of oxide layers is improved in the present invention because the bond energy of the Si-H and Si-OH bonds is increased by replacing the hydrogen atoms with deuterium atoms. The Si-D and Si-OD bonds thus formed provide completed silicon dangling bonds that are less likely to break when exposed to electrical stresses. Therefore, the deuterium containing devices of the present invention have improved stability, quality, and reliability.

Ex. 1006, 4, l. 35 – p. 5, l. 5.

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[8] VLSI stands for "very large scale integration." Ex. 1010 (THOMAS E. DILLINGER, VLSI ENGINEERING 4 (Prentice Hall, 1988)).

2. Hwang (Ex. 1004)

Hwang is titled “Improved Reliability Characteristics of Submicrometer nMOSFET’s with Oxynitride Gate Dielectric Prepared by Rapid Thermal Oxidation in N_20.” Ex. 1004, 495. Hwang states:

> The improvement of interfacial quality has been attributed to nitrogen incorporation at the Si/SiO_2 interface. However, nitridation in NH_3 causes significant electron trapping, which is the major drawback of nitride oxide. Recently, we have reported new oxynitride gate dielectrics grown in N_2O. Compared with conventional rapid thermally grown oxide, the new oxynitride dielectrics show very large charge to breakdown, less charge trapping, and less interface state generation under constant current stress. . . .
>
> In this letter, we report the reliability characteristics of submicrometer nMOSFET’s with oxynitride gate dielectric under hot-carrier stress. Compared with conventional rapid thermally grown oxide, oxynitride shows significantly less degradation under channel hot-electron stress. According to lifetime calculation, oxynitride exhibits approximately one order of magnitude longer lifetime than that of control oxide.

Id. (footnotes omitted).

3. Deal (Ex. 1008)

Deal, titled “Complementary Insulated Gate Field Effect Transistor Structure And Process For Fabricating The Structure,” discloses a field effect transistor with an interface between a semi-conductive silicon layer and a gate oxide layer. Ex. 1008, 1; col. 9, ll. 54-56. Deal expressly describes hydrogen passivation of the structure after the metal contacts are formed. *Id*. at col. 9, ll. 33-53; Ex. 1001 (Reed Decl.) ¶ 16. Deal does not disclose using deuterium for the passivation.

C. Claims 1 And 2 As Obvious Over Lisenker and Hwang

Micron relies on Lisenker as teaching the subject matter of claims 1 and 2 except for an express teaching of a gate oxide layer that comprises silicon oxynitride. Pet. 23-24. We agree that Lisenker teaches such subject matter. *See, e.g.*, Ex. 1006, 11, ll. 5-8 ("Especially preferred devices of this invention are MOS transistors in which the gate oxide silicon layer contains additional deuterium containing bonds.").[9]

Micron relies on Hwang as teaching a gate oxide layer comprising silicon oxynitride to reduce degradation under channel hot electron stress and increase device lifetime relative to a device comprising conventional silicon dioxide. Pet. 20; Ex. 1001 (Reed Decl.) ¶¶ 35, 37. We agree that Hwang teaches such subject matter, and the University has not argued otherwise. *See* Ex. 1004, 495.

Dr. Reed testified that, in light of at least Hwang, it was well known that silicon oxynitride was a suitable material that could be used as the gate insulating layer, and that it would have been obvious to substitute the silicon oxynitride of Hwang for the silicon dioxide layers disclosed by Lisenker. Ex. 1001 ¶¶ 37, 38; *see also KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 416 (2007) ("[W]hen a patent claims a structure already known in the prior art that is altered by the mere substitution of one element for another known in the field, the combination must do more than yield a predictable result.").

The University has not argued that the Micron-asserted modification of Lisenker in view of Hwang involves more than the simple substitution of one known element for another. Rather, the University argues that (1) one

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[9] We credit Dr. Reed's testimony that "in the semiconductor industry, the term 'MOS transistor' is understood to mean MOS field effect transistor." Ex. 1001 (Reed Decl.) ¶ 41.

of ordinary skill would have ignored Lisenker altogether; (2) one of ordinary skill would read Lisenker as limited to pre-metallization passivation; and (3) increased resilience to hot carrier effects is not inherent in Lisenker. PO Resp. 9-13

We disagree with each of these arguments, as discussed below.

1. One Of Ordinary Skill Would Not Have Ignored Lisenker

The University argues that the fundamental theory underlying Lisenker's teachings is that "the Si-D bond is significantly stronger than the Si-H bond." PO Resp. 9 (providing no citation to Lisenker).[10] But, according to the University, Lisenker erroneously relies on energy values for bonds <u>not</u> at the interface. *Id*. The University further argues that a person of ordinary skill in the art at the time of the invention would have known that "the energies for Si-D and Si-H bond disassociation *at the silicon surface* are identical or substantially identical." *Id*. (emphasis added). Therefore, the University reasons, such a person "would have concluded that the teachings of Lisenker were immaterial to the problem facing the inventors of the ['387] patent, *i.e.*, how to solve for hot carrier effects involving bonds at the silicon substrate." *Id*. at 10 (citing *In re Young*, 927 F.2d 588 (Fed. Cir. 1991)).

Contrary to the implication of the University's argument, however, the scope of the prior art is not limited to solutions that are directed to the problem the patentees set out to solve. *KSR*, 550 U.S. at 419 ("In determining whether the subject matter of a patent claim is obvious, neither

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[10] Lisenker states that "[t]he stability of oxide layers is improved in the present invention because the bond energy of the Si-H and Si-OH bonds is increased by replacing the hydrogen atoms with deuterium atoms."
Ex. 1006, 4, l. 35 – 5, l. 1.

the particular motivation nor the avowed purpose of the patentee controls. What matters is the objective reach of the claim. If the claim extends to what is obvious, it is invalid under § 103."). Additionally, we disagree with the further implication that Lisenker is not concerned with solving for hot carrier effects involving bonds at the silicon surface (or silicon-silicon dioxide interface). *See* Ex. 1006, 4, ll. 2-12 (discussion by Lisenker of problems caused by hot electrons at the silicon-silicon dioxide interface); Fig. 1 (illustrating an improved silicon-silicon dioxide interface in accordance with the Lisenker invention).

Also, the University's reliance on *In re Young* is not persuasive. *Young* does not support the proposition that a prior art reference may be ignored. *Young*, 927 F.2d at 591 ("Even if tending to discredit [the] Carlisle [patent], [the] Knudsen [article] cannot remove Carlisle from the prior art. Patents are part of the literature of the art and are relevant for all they contain."). In *Young*, the court held that, "[w]hen prior art contains apparently conflicting references, the Board must weigh each reference for its power to suggest solutions to an artisan of ordinary skill." *Id*. Here, the University has presented evidence conflicting, allegedly, with Lisenker's underlying theory of operation. But, the University has not provided a reference conflicting with Lisenker's express teaching that "deuterium containing devices of the present invention have improved stability, quality, and reliability." Ex. 1006, 5, ll. 4-5. Accordingly, we are not persuaded that a person of ordinary skill in the art would have ignored Lisenker.

2. Lisenker Is Not Limited To Pre-Metallization Passivation

Lisenker is not limited to annealing in, or passivation with, deuterium prior to formation of the metal contacts. Rather, the substitution of deuterium for hydrogen "can be implemented throughout the VLSI fabrication procedure." Ex. 1006, 8, ll. 29-30. The University characterizes this as an "isolated passage from Lisenker." PO Resp. 12. But, it is not. Lisenker includes numerous additional teachings that undermine the University's argument that Lisenker's use of deuterium is limited to pre-metallization passivation, including the following:

> "In general, any hydrogen containing material used in VLSI fabrication can be replaced with corresponding deuterium containing material." Ex. 1006, 4, ll. 32-34.
>
> "In one aspect of the present invention, VLSI fabrication flows employ deuterium contained compounds in many or all of the fabrication steps that would normally employ hydrogen or a hydrogen containing compound." *Id.* at 5, ll. 6-9.
>
> "The formation of Si-D and Si-OD bonds is accomplished in the present invention by contacting a silicon wafer with deuterium or a deuterium containing compound before, during, and/or after formation a device oxide layer." *Id.* at 6, ll. 10-14.
>
> "A typical fabrication procedure will include various doping, etching, annealing, deposition, cleaning, passivation, and oxidation steps. In each instance in which hydrogen or a hydrogen containing compound is employed, deuterium or a deuterium containing compound can be used in its place." *Id.* at 8, ll. 30-35.

The University, citing a 1995 publication, previously conceded that "post metal hydrogen annealing had been in widespread use in the semiconductor industry for many years." Ex. 1011 ¶ 15; *see also* Ex. 1001 (Reed Decl.) ¶ 15 (Micron witness testifying that it was "standard practice" in the industry). Thus, as Lisenker teaches the substitution of deuterium "[i]n each instance" in which hydrogen is otherwise used, and "throughout the VLSI fabrication procedure," it teaches that substitution during post-metal annealing. Ex. 1006, 8, ll. 29-37.

To support its argument that Lisenker is limited to pre-metallization passivation, the University cites the following deposition testimony of Micron witness Dr. Reed, taken during his cross-examination:

> Q. So Lisenker is teaching that one should not anneal the deuterium until after metallization?
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> MR. RIFFE: Objection, form.
>
> THE WITNESS: That's not the way I read this.

PO Resp. 13 (citing Ex. 2013, 88, ll. 13-17). This testimony does not support the University's argument. As is evident on its face, counsel for the University asked Dr. Reed whether Lisenker was *limited* to post-metallization passivation, and he answered in the negative. That answer is consistent with the disclosure of Lisenker. *See, e.g.*, Ex. 1006, 8, ll. 29-30 ("The present invention can be implemented throughout the VLSI fabrication procedure.").

3. Lisenker Teaches Increased Resilience To Hot Carrier Effects And Increased Lifetime

The University argues that Lisenker cannot teach the increased "resilience . . . to hot carrier effects" limitation of claim 1 (or, by implication, the increased "lifetime" limitation of claim 2) because it lacks deuterium at the interface. PO Resp. 11.[11] More specifically, the University

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[11] Although the University does not address directly claim 2 on page 11 of its Patent Owner Response, it does so indirectly by later characterizing the increased "lifetime" limitation of claim 2 as narrower than the increased "resilience . . . to hot carrier effects" limitation of claim 1. PO Resp. 15.

argues that Lisenker is limited to deuterium passivation that is performed only pre-metallization (i.e., before the metal contacts on the device are formed) and, thus, the deposited deuterium migrates away from the interface during subsequent processing. *Id*. As discussed above, however, Lisenker is not limited to pre-metallization deuterium passivation.

Contrary to the University's assertions, Lisenker expressly states that deuterium is retained at the interface.

> The regions where the deuterated bonds provide the greatest benefit in terms of device performance is at the interface of silicon-silicon dioxide layers. Thus, the semiconductor devices of this invention will have at this interface a ratio of Si-OD plus Si-D bonds to Si-OH plus Si-H bonds that is substantially greater than ratio of naturally occurring deuterium to hydrogen.

Ex. 1006, 10, ll. 29-35. Lisenker also includes claims to such devices, including, for example, a semi-conductor device having an interface between a silicon dioxide layer and a silicon surface "wherein the ratio of Si-OD plus Si-D bonds to Si-OH plus Si-H bonds is greater than about 99:1." *Id*. at 12, ll. 3-9 and 15-17.

Thus, Lisenker teaches devices having increased amounts of deuterium at the interface relative to other prior art devices. Longer device lifetimes due to increased resilience to hot electron effects is an inherent result of greater deuterium retained at the interface. The University does not dispute that fact, and, indeed, it is the basis of the claims of its patent. PO Resp. 2; *see also King Pharms., Inc. v. Eon Labs, Inc.*, 616 F.3d 1267, 1276 (Fed. Cir. 2010) ("Because the '128 patent discloses no more than taking metaxalone with food, to the extent such a method increases the bioavailability of metaxalone, the identical prior art method does as well.").

Additionally, Lisenker expressly recognizes the improvement. Ex. 1006, 5, ll. 4-5 (“Therefore, the deuterium containing devices of the present invention have improved stability, quality, and reliability.”).

Micron has made a prima facie case that the subject matter of claims 1 and 2 would have been obvious over Lisenker and Hwang.

D. Claims 1 And 2 As Obvious Over Lisenker In View Of Hwang And Deal

For this ground, Micron additionally relies on Deal as providing an express teaching of post-fabrication passivation, albeit in hydrogen. Pet. 29-30. Deal does provide such a teaching (*see* Ex. 1008, col. 9, ll. 33-53), which the University does not dispute. Relying in part on Dr. Reed’s testimony, Micron contends that it would have been obvious to one of ordinary skill in the art to have incorporated Deal’s post-fabrication step into Lisenker (as modified by Hwang) because Deal also is directed to improving device quality. Pet. 30; Ex. 1001 ¶ 44; Ex. 1008, col. 9, ll. 46-51. The incorporated post-fabrication passivation step would employ deuterium. *See, e.g.*, Ex. 1006, 8, ll. 30-35 (“In each instance in which hydrogen or a hydrogen containing compound is employed, deuterium or a deuterium containing compound can be used in its place.”).

The University does not present any arguments against unpatentability on this ground beyond its arguments against unpatentability based on Lisenker and Hwang, which we already have found unpersuasive. PO Resp. 15-16. Thus, even if claims 1 and 2 require post-fabrication passivation with deuterium (contrary to our construction above), Micron has made a prima facie case that such subject matter would have been obvious over Lisenker in view of Hwang and Deal.

E. Claims 1 And 2 As Obvious Over Deal In View Of Hwang and Lisenker

For this ground, the University uses the same references as above, but proposes a modification of Deal in view of the other references, as opposed to starting with Lisenker.

Micron asserts that Deal teaches "[a] field effect transistor having an interface between a semiconductive silicon layer and a gate oxide layer" as required by claims 1 and 2. Pet. 35. We agree that Deal teaches such subject matter, and the University has not argued otherwise. *See, e.g.*, Ex. 1008, col. 9, ll. 54-56.

Micron relies on Hwang as teaching a gate oxide layer comprising silicon oxynitride to reduce degradation under channel hot electron stress and increase device lifetime relative to a device comprising conventional silicon dioxide. Pet. 36; Ex. 1001 (Reed Decl.) ¶¶ 35, 45. We agree that Hwang teaches such subject matter, and the University has not argued otherwise. Ex. 1004, 495.

Dr. Reed testified that, in light of at least Hwang, it was well known that silicon oxynitride was a suitable material that could be used as the gate insulating layer, and that it would have been obvious to substitute the silicon oxynitride of Hwang for the silicon dioxide layers disclosed by Deal. Ex. 1001 ¶¶ 46, 47; *see also KSR*, 550 U.S. at 416 ("[W]hen a patent claims a structure already known in the prior art that is altered by the mere substitution of one element for another known in the field, the combination must do more than yield a predictable result.").

Finally, Micron relies on Lisenker as teaching passivation of the interface with deuterium, which results in increased resilience of the field effect transistor to hot electron effects. Pet. 37-38. Dr. Reed testified that it would have been obvious to substitute deuterium for hydrogen in Deal's post-fabrication passivation step because "Lisenker suggests that 'any hydrogen containing material used in VLSI fabrication can be replaced with corresponding deuterium containing material.'" Ex. 1001 ¶ 50 (quoting Ex. 1008, col. 4, ll. 32-34).

The University does not present any arguments against unpatentability on this ground beyond its arguments against unpatentability based on Lisenker and Hwang, which we already have found unpersuasive. PO Resp. 16. Thus, even if claims 1 and 2 require post-fabrication passivation with deuterium (contrary to our construction above), Micron has made a prima facie case that such subject matter would have been obvious over Deal in view of Hwang and Lisenker.

F. Objective Indicia

The University argues that certain objective indicia, or secondary considerations, demonstrate non-obviousness of the claims. *See Graham v. John Deere Co.,* 383 U.S. 1, 17-18 (1966) ("Such secondary considerations as commercial success, long felt but unsolved needs, failure of others, etc., might be utilized to give light to the circumstances surrounding the origin of the subject matter sought to be patented. As indicia of obviousness or nonobviousness, these inquiries may have relevancy."). In particular, the University argues that the claimed invention of the '387 patent yielded unexpected results and that others failed to eliminate hot carrier effects. PO Resp. 4-8.

The University's evidence of unexpected results is not persuasive because it does not compare the results of the claimed invention of the '387 patent to the closest prior art, which is Lisenker. *See* PO Resp. 4-7; *In re Baxter Travenol Labs.*, 952 F.2d 388, 392 (Fed. Cir. 1991) ("[W]hen unexpected results are used as evidence of nonobviousness, the results must be shown to be unexpected compared with the closest prior art."). Lisenker expressly discloses that "deuterium containing devices of the present invention have improved stability, quality, and reliability" relative to those containing hydrogen. Ex. 1006, 5, ll. 4-5. Thus, when properly considering Lisenker, the beneficial results of substituting deuterium for hydrogen are expected. *See In re Skoner*, 517 F.2d 947, 950 (CCPA 1975) ("Expected beneficial results are evidence of obviousness of a claimed invention. Just as unexpected beneficial results are evidence of unobviousness.").

With respect to the alleged failure of others, the University argues that the "continued use [in the prior art] of hydrogen passivation reflects a systemic failure in the art to solve the problem faced by the inventors of the '387 patent." PO Resp. 8. Thus, the University fails to account for the prior art teachings of Lisenker, which already had proposed the substitution of deuterium for hydrogen during passivation, and indeed, throughout the VLSI fabrication process.

Having considered all of the evidence, including Patent Owner's secondary considerations evidence, we conclude that the claims would have been obvious.

CONCLUSION

Petitioner, Micron, has demonstrated by a preponderance of the evidence that claims 1 and 2 of the ’387 patent are unpatentable as follows:

The Petition is granted as to the following grounds:

claims 1 and 2 as obvious over Lisenker and Hwang;

claims 1 and 2 as obvious over Lisenker in view of Hwang and Deal; and

claims 1 and 2 as obvious over Deal in view of Hwang and Lisenker.

ORDER

In consideration of the foregoing, it is hereby:

ORDERED that claims 1 and 2 of the ’387 patent are CANCELLED.

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