

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

WESTERN DIGITAL TECHNOLOGIES, INC.,
Petitioner,

v.

GODO KAISHA IP BRIDGE 1,
Patent Owner.

IPR2024-01494
Patent 11,968,909 B2

Before JUSTIN T. ARBES, MONICA S. ULLAGADDI, and
JOHN D. HAMANN, *Administrative Patent Judges*.

ARBES, *Administrative Patent Judge*.

DECISION
Granting Institution of *Inter Partes* Review
35 U.S.C. § 314

I. INTRODUCTION

A. Background and Summary

Petitioner Western Digital Technologies, Inc., filed a Petition (Paper 1, “Pet.”) requesting *inter partes* review of claims 1–20 of U.S. Patent No. 11,968,909 B2 (Ex. 1017, “the ’909 patent”) pursuant to 35 U.S.C. § 311(a). Patent Owner Godo Kaisha IP Bridge 1 filed a Preliminary Response (Paper 7, “Prelim. Resp.”) pursuant to 35 U.S.C.

§ 313. Patent Owner also provided, with its Preliminary Response, evidence that it filed with the Office a statutory disclaimer of claims 1–4, 7, and 8 of the '909 patent pursuant to 35 U.S.C. § 253(a) and 37 C.F.R. § 1.321(a). *See* Prelim. Resp. 3 n.1, 38–39; Ex. 2018. Accordingly, no *inter partes* review will be instituted for claims 1–4, 7, and 8. *See* 37 C.F.R. § 42.107(e) (“No *inter partes* review will be instituted based on disclaimed claims.”); Patent Trial and Appeal Board Consolidated Trial Practice Guide (Nov. 2019), 52, *available at* <https://www.uspto.gov/TrialPracticeGuideConsolidated> (“[A] patent owner may file a statutory disclaimer of one or more challenged claims to streamline the proceedings. . . . Where one or more challenged claims remain, the Board’s decision on institution would be based solely on the remaining claims.”).

Pursuant to 35 U.S.C. § 314(a), the Director may not authorize an *inter partes* review unless the information in the petition and preliminary response “shows that there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition.” *See* 37 C.F.R. § 42.4(a) (“The Board institutes the trial on behalf of the Director.”). For the reasons that follow, we institute an *inter partes* review as to claims 5, 6, and 9–20 of the '909 patent on all grounds of unpatentability asserted with respect to those claims in the Petition.

B. Related Matters

The parties indicate that the '909 patent is the subject of *Godo Kaisha IP Bridge I v. Western Digital Technologies, Inc.*, No. 24-cv-06555 (N.D. Cal.) (transferred from D. Del.) (“the district court case”), and *Godo Kaisha IP Bridge I v. Seagate Technology LLC*, No. 24-cv-03691

(D. Minn.)(transferred from D. Del.). *See* Pet. 71; Paper 8, 2. Petitioner filed petitions challenging patents related to the '909 patent in IPR2024-01384 (denied), IPR2024-01385 (denied), IPR2024-01386 (denied), IPR2024-01447 (instituted), IPR2024-01448 (denied), IPR2024-01449 (denied), IPR2024-01493 (pending), and IPR2025-00701 (pending).

C. The '909 Patent

The '909 patent discloses a “magnetic tunnel junction” (MTJ) device with a “high magnetoresistance.” Ex. 1017, col. 1, ll. 37–40. The '909 patent describes that “[m]agnetoresistive random access memories (MRAMs) refer to a large-scale integrated memory circuit that is expected to replace the currently widely used [dynamic random-access memory (DRAM)] memories.” *Id.* at col. 1, ll. 44–47. The patent further explains that “a MTJ device comprises a tunnelling junction structure in which a tunnel barrier (to be hereafter also referred to as a ‘barrier layer’) made of an oxide is sandwiched between a first and a second electrode made of a ferromagnetic metal.” *Id.* at col. 1, ll. 54–58, Figs. 8(A), 8(B). Objectives of the patent are to “increase the output voltage of a MTJ device” and “provide a memory device with a high magnetoresistance for stable operation.” *Id.* at col. 3, ll. 1–4.

Figure 1(B) of the '909 patent is reproduced below:

FIG. 1 (B)



Figure 1(B) depicts the MTJ device comprising “a first Fe (001) layer 1, a second Fe (001) layer 5, and a single-crystalline MgOx (001) layer 3 or a poly-crystalline MgOx ($0 < x < 1$) layer 3 sandwiched therebetween, the polycrystalline layer having the (001) crystal plane preferentially oriented therein.” Ex. 1017, col. 5, ll. 47–49, 51–57. Further, the patent explains, “[w]hen there are oxygen vacancy defects, the potential barrier height of the MgO tunnel barrier is thought to decrease (such as in the range of 0.10 to 0.85 eV; more specifically, 0.2 to 0.5 eV), which is thought to result in an increase in the tunneling current.” *Id.* at col. 7, ll. 19–23. “Using the method according to the present embodiment of the invention, a tunnel barrier height of approximately 0.3 eV is expected, indicating that the resistance of the tunnel barrier can be lowered.”¹ *Id.* at col. 7, ll. 28–31. The '909 patent notes that the “aforementioned tunnel barrier height ϕ was determined by fitting the electric conductance characteristics of the MTJ device (the relationship between tunnel current density J and bias voltage V)

¹ Petitioner explains that “MTJ behavior is explained by quantum mechanics” and, for a MTJ device, “the tunnel barrier height represents the difference between the bottom of the conduction band of the tunnel barrier layer and the Fermi level of electrons in the conductor,” where “[e]lectrons that lie close to the Fermi level participate in tunneling.” Pet. 7–9 (citing Ex. 1024 ¶¶ 45–49).

onto the Simmons' formula . . . based on the WKB approximation, using the least squares method." *Id.* at col. 7, ll. 39–45.

D. Illustrative Claims

Challenged claims 9 and 15 of the '909 patent are independent. Claims 5 and 6 depend from disclaimed claim 1, claims 10–14 depend from claim 9, and claims 16–20 depend from claim 15. Claims 1 and 5 recite the following (with letter designations used in the Petition to refer to the various limitations):

1. [pre] A magnetoresistive device comprising a magnetic tunnel junction structure comprising a multi-layer material stack including:

[a] first and second ferromagnetic material layer; and

[b] a tunnel barrier layer between the first and second ferromagnetic material layers such that the tunnel barrier layer is above the first ferromagnetic material layer and below the second ferromagnetic material layer,

[c] wherein said tunnel barrier layer comprises crystalline MgO_x (001) with oxygen vacancy defects and ($0 < x < 1$).

5. The magnetoresistive device of claim 1, wherein a barrier height of the tunnel barrier layer is in a range of 0.1 eV to 0.85 eV.

E. Evidence

Petitioner relies on the following prior art:

U.S. Patent No. 7,270,896 B2, filed July 2, 2004, issued Sept. 18, 2007 (Ex. 1062, "Parkin");

European Patent Application Publication
No. EP1391942A1, published Feb. 25, 2004 (Ex. 1027,
"Nagahama");

Japanese Patent Application Publication
No. JP2002-204004A, published July 19, 2002 (Ex. 1029)
(Ex. 1030, English translation, “Sunai”);

M. Bowen *et al.*, *Large Magnetoresistance in Fe/MgO/FeCo(001) Epitaxial Tunnel Junctions on GaAs(001)*, 79 Appl. Phys. Letters 1655–1657 (2001) (Ex. 1026, “Bowen”);
and

R. J. Soukup & D. E. Speliotis, *Voltage-Current Characteristics for Electrical Conduction Through Thin MgO Films*, 41 J. Appl. Phys. 3229–3236 (1970) (Ex. 1028, “Soukup”).

F. Prior Art and Asserted Grounds

Petitioner asserts that claims 5, 6, and 9–20 of the ’909 patent are unpatentable on the following grounds:

Claims Challenged	35 U.S.C. §	References/Basis
5, 6, 9–20	103(a) ²	Bowen, Soukup

² The Leahy-Smith America Invents Act, Pub. L. No. 112-29, 125 Stat. 284 (2011) (“AIA”), amended 35 U.S.C. § 103. Because the challenged claims of the ’909 patent have an effective filing date before the effective date of the applicable AIA amendment, we refer to the pre-AIA version of 35 U.S.C. § 103. *See* Pet. 16; Ex. 1017, codes (22), (63). Petitioner asserts in the Petition that claims 1 and 8 would have been obvious “over Bowen alone or in view of Soukup”; claims 2–6 and 9–20 would have been obvious “over Bowen in view of Soukup”; claim 7 would have been obvious “over Bowen in view of Sunai or Parkin and optionally Soukup”; claims 1 and 8 would have been obvious “over Nagahama alone or in view of Soukup”; claims 2–6 and 9–20 would have been obvious “over Nagahama in view of Soukup”; and claim 7 would have been obvious “over Nagahama in view of Sunai or Parkin and optionally Soukup.” Pet. 16. As explained above, Patent Owner disclaimed claims 1–4, 7, and 8. *See supra* Section I.A; Ex. 2018. Accordingly, we consider the asserted grounds only as to claims 5, 6, and 9–20.

Claims Challenged	35 U.S.C. §	References/Basis
5, 6, 9–20	103(a)	Nagahama, Soukup

II. ANALYSIS

A. Legal Standards

A claim is unpatentable for obviousness if, to one of ordinary skill in the pertinent art, “the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made.” *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007) (quoting 35 U.S.C. § 103(a)). The question of obviousness is resolved on the basis of underlying factual determinations, including “the scope and content of the prior art”; “differences between the prior art and the claims at issue”; and “the level of ordinary skill in the pertinent art.” *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966). Additionally, secondary considerations, such 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.” *Id.* When conducting an obviousness analysis, we consider a prior art reference “not only for what it expressly teaches, but also for what it fairly suggests.” *Bradium Techs. LLC v. Iancu*, 923 F.3d 1032, 1049 (Fed. Cir. 2019).

A patent claim “is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art.” *KSR*, 550 U.S. at 418. An obviousness determination based on a combination of references requires finding “both ‘that a skilled artisan would have been

motivated to combine the teachings of the prior art references to achieve the claimed invention, and that the skilled artisan would have had a reasonable expectation of success in doing so.” *Intelligent Bio-Sys., Inc. v. Illumina Cambridge Ltd.*, 821 F.3d 1359, 1367–68 (Fed. Cir. 2016) (quoting *Kinetic Concepts, Inc. v. Smith & Nephew, Inc.*, 688 F.3d 1342, 1360 (Fed. Cir. 2012)); *see KSR*, 550 U.S. at 418 (for an obviousness analysis, “it can be important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in the way the claimed new invention does”).

“Although the *KSR* test is flexible, the Board ‘must still be careful not to allow hindsight reconstruction of references . . . without any explanation as to *how* or *why* the references would be combined to produce the claimed invention.” *TriVascular, Inc. v. Samuels*, 812 F.3d 1056, 1066 (Fed. Cir. 2016) (quoting *Kinetic Concepts*, 688 F.3d at 1368). Further, an assertion of obviousness “cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.” *KSR*, 550 U.S. at 418 (quoting *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006)); *accord In re NuVasive, Inc.*, 842 F.3d 1376, 1383 (Fed. Cir. 2016) (stating that “conclusory statements” amount to an “insufficient articulation[] of motivation to combine”; “instead, the finding must be supported by a ‘reasoned explanation’” (quoting *In re Lee*, 277 F.3d 1338, 1342 (Fed. Cir. 2002))); *In re Magnum Oil Tools Int’l, Ltd.*, 829 F.3d 1364, 1380 (Fed. Cir. 2016) (“To satisfy its burden of proving obviousness, a petitioner cannot employ mere conclusory statements. The petitioner must instead articulate specific

reasoning, based on evidence of record, to support the legal conclusion of obviousness.”).

B. Level of Ordinary Skill in the Art

Petitioner argues that at the time of the ’909 patent (2004), a person of ordinary skill in the art would have had “a Ph.D. in electrical engineering, physics, materials science, or a related field, and at least one year of experience in the research, design, and/or development of magnetic/spintronic devices, or the equivalent,” or “a Master’s degree in electrical engineering, physics, materials science, or a related field, and four years of experience in the research, design, and/or development of magnetic/spintronic devices, or the equivalent,” where “[l]ess work experience may be compensated by a higher level of relevant education, and vice versa.” Pet. 18–19 (citing Ex. 1024 ¶ 25). Patent Owner applies Petitioner’s definition of the level of ordinary skill in the art for purposes of its Preliminary Response. Prelim. Resp. 17. Based on the record presented, including our review of the ’909 patent and the types of problems and solutions described in the ’909 patent and cited prior art, we agree with Petitioner’s proposed definition of the level of ordinary skill in the art and apply it for purposes of this Decision.

C. Claim Interpretation

We interpret each challenged claim

using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. 282(b), including construing the claim in accordance with the ordinary and customary meaning of such claim as understood by one of

ordinary skill in the art and the prosecution history pertaining to the patent.

37 C.F.R. § 42.100(b). Petitioner argues that “the claim terms should be given their plain and ordinary meaning and no claim construction is necessary.” Pet. 15. Patent Owner does not propose interpretations of any claim terms in its Preliminary Response. We conclude that no express interpretation of any claim term is necessary to determine whether to institute an *inter partes* review in this proceeding. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (“Because we need only construe terms ‘that are in controversy, and *only to the extent necessary* to resolve the controversy,’ we need not construe [a particular claim limitation] where the construction is not ‘material to the . . . dispute.’” (citation omitted) (emphasis added)).

D. Obviousness Ground Based on Bowen and Soukup

Petitioner contends that claims 5, 6, and 9–20 are unpatentable over Bowen and Soukup under 35 U.S.C. § 103(a), citing the testimony of Jeffrey Bokor, Ph.D., as support. Pet. 19–25, 33–37, 42–46 (citing Ex. 1024). Patent Owner responds. Prelim. Resp. 17–36. We are persuaded that Petitioner has established a reasonable likelihood of prevailing on its asserted ground as to claim 5. *See* 37 C.F.R. § 42.108(a).

1. Bowen

Bowen discloses that the “magnetoresistance of magnetic tunnel junctions (MTJs) is of uncontested interest for important applications with, in particular, promising perspectives for the fabrication of nonvolatile memories (Magnetic RAM).” Ex. 1026, 1655 (footnote omitted). Bowen

“present[s] tunneling experiments on Fe(001)/MgO(20 Å)/FeCo(001) single-crystal epitaxial junctions of high quality grown by sputtering and laser ablation.” *Id.* (Abstract).

Bowen discloses that “numerical calculations of spin-dependent tunneling and [tunnel magnetoresistance ratio (TMR)] have been developed for single crystal MTJs such as Co/Al₂O₃/Co(100), Fe/ZnSe(100), or Fe/MgO(100),” and that “a correct depiction of the spin-dependent tunneling properties of epitaxial MTJs must transcend the simple potential barrier image and take into account the interplay of electronic structure between metal and insulator.” Ex. 1026, 1655 (footnotes omitted). Bowen describes that “much work has been expended to characterize the growth and electrical behavior of ultrathin MgO layers,” and presents “experimental results showing large TMR values in Fe(001)/MgO(001)/FeCo(001) epitaxial tunnel junctions.” *Id.*

Tests were performed on single-crystal epitaxially grown structures in a Fe(001)/MgO(001)/FeCo(001) tunnel junction. Ex. 1026, 1655. With a barrier layer of 20 Å thickness, Bowen determined a barrier height of 0.9 eV, and calculated a barrier height using “Simmons’ equations” of 1.1 eV for a barrier thickness of 15 Å. *Id.* at 1656.

2. Soukup

Soukup is an article published in 1970 titled “Voltage-Current Characteristics for Electrical Conduction Through Thin MgO Films.” Ex. 1028, 3229. Soukup addresses the “voltage-current characteristics of Au-MgO-Au thin-film emission diodes formed by electron beam evaporation of Au and MgO.” *Id.* (Abstract). Soukup describes that the

“voltage-current characteristics” of these diodes “are consistent with an expression derived for Schottky field emission into the conduction band of the oxide,” but test results “indicate a potential barrier height of about 0.72 eV when determined from the zero-field intercept of the straight line $\log I$ vs $V^{1/2}$ plot and about 0.33 eV when obtained from an Arrhenius plot.” *Id.* Soukup’s measurements were based on “samples . . . fabricated by evaporation of the Au and MgO to form films on a glass substrate.” *Id.* at 3229–3230. Soukup states that “[t]he apparent barrier height determined from the zero-field intercept went up for increasing oxygen pressure and the barrier height determined from the Arrhenius plot went down.” *Id.* at 3229 (Abstract).

3. Claim 5

Petitioner argues that Bowen and Soukup collectively teach all of the limitations of claim 5. Pet. 19–25, 33–36. With respect to parent claim 1, Petitioner contends that Bowen teaches a MTJ device having a “first and second ferromagnetic material layer” (i.e., the “Fe bottom electrode” and “FeCo top electrode”) and a “tunnel barrier layer” (i.e., the “MgO barrier” layer) between the first ferromagnetic material layer and second ferromagnetic material layer. *Id.* at 19–23. With respect to the limitation that “said tunnel barrier layer comprises crystalline MgO_x (001) with oxygen vacancy defects and ($0 < x < 1$),” Petitioner argues that Bowen teaches “single-crystalline MgO_x (001) where $0 < x < 1$, a mathematical notation indicating less than a one-to-one stoichiometric ratio of oxygen to magnesium (i.e., oxygen vacancy defects) in the MgO layer.” *Id.* at 23. Petitioner further contends that “MgO with oxygen vacancy defects was

inherently MgO_x where $0 < x < 1$ because x has to be greater than 0 to constitute MgO and less than 1 to constitute nonstoichiometric MgO with oxygen vacancies,” and Bowen attributed its 0.9 eV barrier height to “oxygen vacancy defects (stoichiometric inhomogeneities) in the MgO barrier.” *Id.* at 23–24 (citing Ex. 1026, 1656). Petitioner “[a]lternatively” relies on Soukup, arguing that a person of ordinary skill in the art “would have understood that Bowen’s and/or Soukup’s stoichiometric inhomogeneities in the MgO barrier referred to oxygen vacancy defects in the MgO crystal” and “would also have been motivated to apply Soukup’s teachings about oxygen vacancy defects to Bowen’s MgO MTJ to improve tunneling current, increase TMR, and enhance MRAM performance for the same reasons as explained” for claim 5. *Id.* at 24–25 (emphasis omitted). Patent Owner does not dispute Petitioner’s arguments regarding the limitations of claim 1 (which has been disclaimed), and we determine that Petitioner has made a sufficient showing on this record with respect to the limitations of parent claim 1.

Claim 5 depends from claim 1 and recites that “a barrier height of the tunnel barrier layer is in a range of 0.1 eV to 0.85 eV.” Petitioner relies on Bowen and Soukup, asserting that the combination teaches or suggests a barrier height for the MgO layer in the claimed range. Pet. 33 (citing Ex. 1024 ¶¶ 165–180). Petitioner contends that although Bowen discloses a barrier height of 0.9 eV for its MgO barrier device, “Soukup observed a ‘barrier height’ within the claimed range of ‘about 0.33 eV’ for its MgO barrier.” *Id.* (citing Ex. 1024 ¶ 167; Ex. 1026, 1656; Ex. 1028, 3229 (Abstract), 3231–3232, Fig. 5, Table I) (emphasis omitted). Petitioner asserts that “Soukup taught that oxygen vacancy defects had an impact on

the barrier height for MgO.” *Id.* at 33–34 (citing Ex. 1024 ¶ 168; Ex. 1028, 3232). For support, Petitioner cites Soukup’s disclosure that “[t]he zero-field intercept of the Schottky plots is a function of oxygen pressure with the lower intercept (higher barrier?) present for the devices fabricated with more oxygen present during MgO deposition, which could mean more stoichiometric oxide films.” Ex. 1028, 3232; *see* Pet. 33–34.

Petitioner argues that a person of ordinary skill in the art “would have been motivated to apply Soukup’s teachings about an MgO thin film barrier with a ‘barrier height’ of ‘about 0.33 eV’ to Bowen’s MgO barrier.” Pet. 34 (citing Ex. 1024 ¶¶ 169–171; Ex. 1028, 3229 (Abstract), 3232, 3236). Petitioner asserts that “[a]ccording to the equation for TMR,^[3] lowering the resistance (barrier height) for parallel electrons (R_p) would improve TMR.” *Id.* (citing Ex. 1017, col. 5, ll. 10–16; Ex. 1024 ¶ 169; Ex. 1027 ¶ 2; Ex. 1035, 3273). Petitioner contends that “TMR was an ‘important parameter’ for improving MRAM performance,” so skilled artisans, including the authors of Bowen, were long “interested in increasing TMR to enable better performing MRAM.” *Id.* (citing Ex. 1024 ¶ 170; Ex. 1026, 1655 (Abstract); Ex. 1055, 2269, 2271).

Petitioner further argues that “Butler^[4] and Mathon^[5] taught that MgO barriers would achieve higher TMRs due to improved symmetry matching

³ A mathematical equation for TMR is “ $\Delta R/R_p = (R_{ap} - R_p)/R_p$,” where R_{ap} is the antiparallel resistance and R_p is the parallel resistance in a MRAM. *See* Ex. 1017, col. 5, ll. 8–16; Pet. 5–6; Prelim. Resp. 2.

⁴ W.H. Butler *et al.*, *Spin-Dependent Tunneling Conductance of Fe/MgO/Fe Sandwiches*, Phys. Rev. B, Vol. 63, 054416 (2001) (Ex. 1044).

⁵ J. Mathon & A. Umerski, *Theory of Tunneling Magnetoresistance of an Epitaxial Fe/MgO/Fe(001) Junction*, Phys. Rev. B, Vol. 63, 220403(R) (2001) (Ex. 1046).

between the MgO barrier and ferromagnetic electrodes, facilitating tunneling of parallel electrons across the barrier compared to antiparallel tunneling.” Pet. 34 (citing Ex. 1024 ¶ 170; Ex. 1044, 1; Ex. 1046, 1). Petitioner contends that an ordinarily skilled artisan “looking to increase TMR of an MgO barrier would have been motivated to explore lower barrier heights to facilitate tunneling of parallel electrons,” so one “seeking to improve Bowen’s MgO MTJ would have looked to Soukup’s teachings about MgO barriers and how defects lowered the barrier height.” *Id.* at 34–35 (citing Ex. 1024 ¶ 171).

Petitioner also asserts that the claimed barrier height range of 0.1–0.85 eV would have been obvious. Pet. 35 (citing Ex. 1024 ¶ 173). Petitioner points out that “[t]he claimed range is only slightly below the barrier height at ‘0.9 eV’ taught by Bowen and others.” *Id.* (citing Ex. 1024 ¶ 173; Ex. 1026, 1656; Ex. 1038, 4725–26). Petitioner further contends that “[o]ne of skill was aware that oxygen vacancy defects impacted the barrier height.” *Id.* Petitioner argues that Bowen “hypothesized that the low barrier height . . . observed, which was ‘lower than half’ of the calculated value for ‘an ultrathin layer’ of MgO, may be due to the ‘presence of stoichiometric . . . inhomogeneities in the insulating film.’” *Id.* at 35–36 (quoting Ex. 1026, 1656; citing Ex. 1024 ¶ 133). Petitioner also refers to Soukup, alleging that “Soukup observed a relationship between barrier height and MgO stoichiometry (oxygen vacancy defects).” *Id.* at 36 (citing Ex. 1028, 3232, 3236). Petitioner argues that “one of skill would have been motivated to adjust oxygen vacancy defects to improve TMR by lowering the barrier height as taught by Soukup.” *Id.*

Finally, Petitioner refers to the disclosure in the '909 patent stating that “[w]hen there are oxygen vacancy defects, the potential barrier height of the MgO tunnel barrier is thought to decrease (such as in the range of 0.10 to 0.85 eV . . .), which is thought to result in an increase in the tunneling current.” Pet. 36 (quoting Ex. 1017, col. 7, ll. 19–22). Petitioner argues that “according to the '909 [p]atent, the tunnel barrier height limitation is inherent when there are oxygen vacancy defects as disclosed by both Bowen and Soukup.” *Id.* (citing Ex. 1026, 1656; Ex. 1028, 3232, 3236). Petitioner also argues that, in the district court case, Patent Owner asserted that “the similar requirement ‘tunnel barrier height in a range of 0.2 to 0.5 eV’ is satisfied by the mere ‘presence of oxygen vacancy defects.’” *Id.* (citing Ex. 1064, 19 (citing Ex. 1001, col. 6, l. 47–col. 7, l. 2)).

Patent Owner makes two sets of arguments in response. First, Patent Owner contends that Petitioner’s “sole alleged reason” why a person of ordinary skill in the art would have been motivated to lower Bowen’s barrier height—“because lowering the barrier height would have allegedly yielded a lower parallel resistance (R_p) and thereby would have allegedly increased the device’s TMR”—is “unsupported.” Prelim. Resp. 18–19. According to Patent Owner, “[n]o credible evidence supports this assertion because, as Petitioner admits, TMR depends on *both* R_p *and* R_{ap} , but Petitioner never explains or even considers how a lower barrier height would affect R_{ap} or how changes to R_{ap} would affect TMR.” *Id.* at 19. The parties cite the following equation for calculating TMR:

$$\text{TMR} = \frac{\Delta R}{R_p} = \frac{R_{ap} - R_p}{R_p}$$

See Pet. 5–6; Prelim. Resp. 2; Ex. 1035,⁶ 3273; Ex. 1017, col. 5, ll. 8–16.

Patent Owner asserts that “Petitioner’s argument is premised on the implicit and entirely unsupported assumption that lowering Bowen’s barrier height would not have also lowered its antiparallel resistance R_{ap} by proportionally the same (or greater) amount than it would have lowered the parallel resistance R_p ,” and, “as a matter of simple math, the parallel resistance R_p must be lowered by a proportionally greater amount than the antiparallel resistance R_{ap} to increase the TMR.” Prelim. Resp. 22–26 (emphasis omitted). Patent Owner argues:

For example, an MTJ device with an R_{ap} of 8 and an R_p of 4 would have a TMR of $(8-4)/4=1$. If R_{ap} and R_p were both reduced proportionally by half, that would not change the TMR: $(4-2)/2=1$. And if R_{ap} is reduced by a proportionally greater amount than R_p , that would have had the *opposite* effect and would have undesirably *decreased* Bowen’s TMR.

Id. at 23.

We disagree with Patent Owner’s arguments based on the current record. Dr. Bokor testifies that “as is evident from the TMR equation, . . . lowering the resistance (barrier height) for parallel spin electrons [(i.e., R_p)] *compared to* antiparallel [(i.e., R_{ap})] improved TMRs.” Ex. 1024 ¶ 169 (citing Ex. 1035, 3273) (emphasis added). Dr. Bokor’s testimony is consistent with the TMR equation above, which has R_p as the only term in the denominator, and reflects that R_p would be lowered disproportionately, or otherwise the TMR would not have “improved.” *Id.* It also appears to be supported by other evidence of record. See Ex. 1035, 3273 (noting the

⁶ J.S. Moodera *et al.*, *Large Magnetoresistance at Room Temperature in Ferromagnetic Thin Film Tunnel Junctions*, 74 Phys. Rev. Lett. 3273–76 (Apr. 17, 1995) (Ex. 1035).

strong influence of tunnel barrier height on $\Delta R/R$). Patent Owner, by contrast, chooses values for R_p and R_{ap} to support its attorney argument that R_p and R_{ap} might be lowered proportionately, or that R_{ap} could be reduced by a proportionally greater amount than R_p , without any evidence that such values are possible. *See* Prelim. Resp. 23.

Patent Owner further contends that Petitioner improperly incorporates Dr. Bokor's testimony by reference in the Petition and that his testimony is conclusory, as he "offers no reasoning or explanation addressing the impact that lowering the barrier height would have on Bowen's antiparallel resistance R_{ap} ." Prelim. Resp. 26–29 (emphasis omitted). We disagree. Throughout its analysis, Petitioner cites individual paragraphs of Dr. Bokor's testimony as well as supporting evidence for its assertions. *See* Pet. 33–36 (citing Ex. 1024 ¶¶ 165–180; Exs. 1026, 1028, 1031, 1035, 1038, 1044, 1046, 1055). Dr. Bokor does cite some additional evidence in the record to explain his opinions (contrary to Patent Owner's argument that his testimony is unsupported), but does not advance theories different from those in the Petition. *See* 37 C.F.R. §§ 42.6(a)(3) ("Arguments must not be incorporated by reference from one document into another document."), 42.22(a)(2) (a petition must include "[a] full statement of the reasons for the relief requested, including a detailed explanation of the significance of the evidence").

At this stage, Petitioner has provided sufficient support for its contention that a person of ordinary skill in the art would have been motivated to lower the 0.9 eV barrier height of Bowen's device, which would lower R_p and in turn increase the TMR. *See* Ex. 1024 ¶¶ 45–49, 169, 171–173, 176. As Petitioner points out, Bowen's barrier height of 0.9 eV

is only slightly above the 0.1–0.85 eV range recited in claim 5. *See* Pet. 35.

Dr. Bokor testifies that

[t]he claimed upper limit of “0.85 eV” is only marginally lower than the “0.9 eV” barrier height disclosed by Bowen and others, and one of skill would have been motivated using Soukup to try to deposit an MgO barrier with a lower barrier height. . . . One of skill applying Soukup’s teachings to Bowen would have readily achieved lowering tunnel barrier height to be within the claimed range.

Ex. 1024 ¶ 173 (citing Ex. 1026, 1656; Ex. 1038, 4725–4726). Thus, based on the current record, the asserted modification to Bowen’s device to lower its barrier height from 0.9 eV to fall within the claimed 0.1–0.85 eV range may not be as substantial as Patent Owner appears to suggest. *See, e.g., Titanium Metals Corp. of Am. v. Banner*, 778 F.2d 775, 783 (Fed. Cir. 1985) (concluding that a claim requiring a titanium alloy with 0.3% Mo and 0.8% Ni would have been obvious over a prior art reference disclosing 0.25% Mo–0.75% Ni and 0.31% Mo–0.94% Ni, where “[t]he proportions are so close that prima facie one skilled in the art would have expected them to have the same properties”).

Soukup also discloses numerous barrier height values within the claimed range. Petitioner points to Soukup’s disclosure of a barrier height of “about 0.33 eV” as shown in Table I. Pet. 33 (citing Ex. 1028, 3229 (Abstract), Table I). Soukup describes the results of testing various devices under different conditions, where apparent barrier heights for the samples were determined using “the zero-field intercept of the straight line $\log I$ versus $I^{1/2}$ plot” and “an Arrhenius plot.” Ex. 1028, 3229 (Abstract), 3230–3232, Fig. 3, Table I.

Table I of Soukup is reproduced below.

TABLE I. Summary of device data.

Device No.	S^a	S_0^b	φ_1^c	φ_2^d	$P_{O_2}^e$
PY-G-11(1)	80	200	0.714	0.33	
PY-G-16(3)	105	...	0.721	...	...
PY-G-17(1)	200	194	0.721	0.33	...
PY-G-18(1)	105	...	0.694	0.34	...
PY-G-18(2)	105	222	0.700	0.35	...
PY-G-19(2)	70	133	0.710	0.33	...
PY-G-20(1)	680	...	0.695	...	...
PY-G-20(3)	680	...	0.695	...	...
PY-G-21(3)	90	...	0.732	0.34	...
PY-G-22(2)	90	209	0.780	0.21	10^{-8}
PY-G-25(3)	60	200	0.823	0.11	10^{-7}
PY-G-38(1)	120	...	1.9, 1.74 ^f	...	10^{-6} , ...

^a S = oxide thickness, in Å.

^b S_0 = overlayer thickness, in Å.

^c φ_1 = barrier obtained by zero intercept method, in eV.

^d φ_2 = barrier obtained from slope of Arrhenius plot, in eV.

^e P_{O_2} = pressure of admitted O_2 during MgO deposition, in Torr.

^f The barrier was obtained from the slope of the Fowler-Nordheim plot.

Table I of Soukup includes the results of analyses of sample test data, with the φ_1 column showing the barrier heights obtained by the zero-field intercept method, the φ_2 column showing barrier heights obtained from the slope of an Arrhenius plot, and the last column (P_{O_2}) showing the pressure of admitted O_2 during MgO deposition. *See* Ex. 1028, 3233. Notably, all of the barrier heights listed, whether determined using the zero-field intercept method or an Arrhenius plot, fall within the 0.1–0.85 eV range.

Second, Patent Owner challenges Petitioner’s reliance on Soukup, arguing that it does not support Petitioner’s asserted motivation to achieve a lower barrier height in Bowen’s device because “Petitioner fails to establish that Soukup discloses a tunnel barrier height” at all. Prelim. Resp. 30. Patent Owner contends that Soukup describes “the behavior of sixty ‘thin-film emission diodes’ comprising MgO depositions between non-magnetic gold electrodes,” not MTJ (i.e., *magnetic* tunnel junction)

devices. *Id.* at 30–31 (emphasis omitted). Patent Owner also argues that the current flow mechanism in Soukup’s devices was “Schottky field emission”: “current flow[] between two electrodes separated by an insulator . . . when electrons in one electrode are sufficiently energized that they overcome the insulator’s resistance to current flow, . . . *i.e.*, the electrons have more energy than required to overcome the insulator’s potential barrier (*e.g.*, the barrier height).” *Id.* at 31–32. Patent Owner contrasts this with “tunneling,” which is “a purely quantum mechanical effect” occurring “when certain conditions of the insulator, electrodes, and electrons are met that result in current flow through the insulator even though the electron’s energy is *not sufficient to overcome* the insulator’s potential barrier that opposes conventional current flow.” *Id.* at 32–33. Patent Owner contends that “Soukup found that tunneling was *not* the current flow mechanism in the diodes he tested because tunnelling was inconsistent with the observed *I-V* (*i.e.*, current-voltage) measurements in several sample diodes,” citing various statements in Soukup regarding Schottky field emission. *Id.* at 33–35 (citing Ex. 1028, 3229, 3230, 3232, 3235–3236).

We disagree with Patent Owner’s arguments based on the current record. Petitioner relies on Bowen, not Soukup, as teaching the three-layer structure of the magnetoresistive device recited in claim 5, and relies on Soukup for Petitioner’s asserted motivation to lower the barrier height of Bowen’s device. *See* Pet. 19–25, 33–36. Also, Soukup does not reach a “definite conclusion[]” as to what current flow mechanism was taking place in its tested devices. *See* Ex. 1028, 3232, 3235–3236. Soukup explains as follows:

If the emission is Schottky emission the barrier height was
a function of the amount of oxygen present in the vacuum system

during deposition of the MgO film with a higher barrier for larger amounts of oxygen present. Raising the oxygen pressure during deposition of the MgO film probably leads to a more stoichiometric film. The barrier height also appeared to become higher with higher temperature.

The only evidence that the current flow mechanism in these devices is not Schottky emission is found in the temperature dependence of the I - V curves. This would still not rule out Schottky emission if the barrier is a function of temperature, becoming higher for higher temperatures. No direct evidence that this is happening was obtained so *no definite conclusions as to the type of current flow mechanism present in these devices can be made.*

Id. at 3236 (emphasis added).

Regardless of the current flow mechanism, Soukup provides some support on this record for Petitioner's asserted modification to modify Bowen's device to have a barrier height slightly lower than 0.9 eV. Petitioner and Dr. Bokor cite Soukup as allegedly teaching an inverse relationship between the amount of oxygen vacancy defects in the barrier layer and the barrier height, i.e., that "a higher level of oxygen vacancy defects lowered the barrier height." *See* Pet. 33–34; Ex. 1024 ¶ 168 ("Soukup taught there was an inverse correlation between oxygen vacancy defects and the barrier height of the MgO layer"). That relationship applies with respect to the zero-field intercept method of determining barrier height.⁷ Soukup discloses that "[t]he zero-field intercept of the Schottky plots is a function of oxygen pressure with the lower intercept (higher barrier?) present for the devices fabricated with more oxygen present during MgO deposition, which could mean more stoichiometric oxide films."

⁷ We recognize that the opposite relationship appears to apply for the Arrhenius plot method. *See* Ex. 1028, 3229 (Abstract), 3233.

Ex. 1028, 3232. Table I similarly shows that, for the zero-field intercept method, the barrier height decreases as oxygen vacancies increase (i.e., as the oxygen pressure admitted during MgO deposition, shown in the P_{O_2} column, decreases). *See id.* at 3233; *see also id.* at 3229 (Abstract) (“[t]he apparent barrier height determined from the zero-field intercept went up for increasing oxygen pressure,” i.e., less oxygen vacancy defects). And, as explained above, all barrier heights determined via the zero-field intercept method in Soukup are within the claimed 0.1–0.85 eV range. Thus, in Petitioner’s proposed combination, Soukup’s zero-field intercept method disclosure provides some support for the asserted modification to modify Bowen’s device to have a slightly lower barrier height (within the claimed 0.1–0.85 eV range).

Finally, we note that, although Petitioner has made a sufficient showing with respect to obviousness, we are not persuaded by Petitioner’s inherency argument. *See Pet.* 36. Specifically, Petitioner has not established that a barrier height of 0.1–0.85 eV is necessarily present in, or the natural result of, a tunnel barrier layer having some amount of oxygen vacancy defects. *See Hospira, Inc. v. Fresenius Kabi USA, LLC*, 946 F.3d 1322, 1329 (Fed. Cir. 2020) (“When the prior art does not expressly disclose a claim limitation, ‘inherency may supply a missing claim limitation in an obviousness analysis.’ . . . Inherency is established in the context of obviousness when ‘the limitation at issue necessarily must be present, or the natural result of the combination of elements explicitly disclosed by the prior art.’”). Petitioner points to the ’909 patent’s statement that “[w]hen there are oxygen vacancy defects, the potential barrier height of the MgO tunnel barrier is thought to decrease (such as in the range of 0.10 to 0.85 eV; more

specifically, 0.2 to 0.5 eV), which is thought to result in an increase in the tunneling current.” Ex. 1017, col. 7, ll. 19–23; *see* Pet. 36. Bowen, however, has “oxygen vacancy defects” in its MgO layer and “[o]xygen vacancies are naturally present in every oxide” according to Petitioner, but Bowen discloses a barrier height of 0.9 eV, which is *outside* the claimed range (albeit only slightly). Pet. 13, 23–24. Thus, Bowen contradicts Petitioner’s assertion that a barrier height within the claimed range of 0.1–0.85 eV is inherent when there are oxygen vacancy defects.

Regardless of its inherency arguments, Petitioner’s other arguments regarding the combination of Bowen and Soukup are sufficient to establish a reasonable likelihood of prevailing at this stage. *See* Pet. 19–25, 33–36; Ex. 1024 ¶¶ 109–136, 165–180. Petitioner has shown a reasonable likelihood of prevailing on its assertion that claim 5 is unpatentable over Bowen and Soukup. Accordingly, we institute review “on all of the challenged claims” remaining after Patent Owner’s statutory disclaimer (i.e., claims 5, 6, and 9–20) “and on all grounds of unpatentability asserted for each” of those claims. *See* 37 C.F.R. §§ 42.107(e), 42.108(a).

4. *Claims 6 and 9–20*

Claim 6 depends from claim 5 and recites that “the barrier height of the tunnel barrier layer is in a range of 0.2 eV to 0.5 eV.” Patent Owner argues claim 5 (reciting the 0.1–0.85 eV range) and claim 6 (reciting the 0.2–0.5 eV range) together, and does not argue separately any of the other challenged claims. Prelim. Resp. 17–36. Claims 9–11, 13, and 14 recite the 0.1–0.85 eV range, and claims 12 and 15–20 recite the 0.2–0.5 eV range. On this record, we disagree with Patent Owner’s arguments with respect to

claim 5 and are persuaded that Petitioner has shown a reasonable likelihood of prevailing on its assertion that claim 5 is unpatentable over Bowen and Soukup. *See supra* Section II.D.3. Accordingly, we need not determine at this time whether Petitioner also has shown a reasonable likelihood of prevailing as to any of the other challenged claims, including those reciting the narrower 0.2–0.5 eV range. *See* 37 C.F.R. § 42.108(a).

E. Obviousness Ground Based on Nagahama and Soukup

Petitioner contends that claims 5, 6, and 9–20 are unpatentable over Nagahama and Soukup under 35 U.S.C. § 103(a), citing the testimony of Dr. Bokor as support. Pet. 47–52, 57–59, 62–67 (citing Ex. 1024). Petitioner’s arguments are similar to those for its asserted ground based on Bowen and Soukup. *Compare id.* at 19–25, 33–37, 42–46, *with id.* at 47–52, 57–59, 62–67; *see* Prelim. Resp. 37 (noting that Petitioner’s arguments for the Nagahama-Soukup ground “closely track” those for the Bowen-Soukup ground, “often word-for-word”). For example, regarding the 0.1–0.85 eV range recited in claim 5, Petitioner argues that Nagahama teaches “an MgO MTJ,” Soukup teaches a barrier height of “about 0.33 eV,” and “[f]or the same reasons explained” with respect to the asserted ground based on Bowen and Soukup, “the claimed tunnel barrier height range of 0.1 to 0.85 eV would have been obvious and is also inherent.” *Id.* at 57–59. Patent Owner responds that Petitioner’s arguments “fail[] for all the same reasons discussed” with respect to the asserted ground based on Bowen and Soukup. Prelim. Resp. 36–38. On this record, we disagree with Patent Owner’s arguments regarding claim 5 and are persuaded that Petitioner has shown a reasonable likelihood of prevailing on its assertion that claim 5 is

unpatentable over Bowen and Soukup. *See supra* Section II.D.3. Accordingly, we need not determine at this time whether Petitioner also has shown a reasonable likelihood of prevailing on its other asserted ground based on Nagahama and Soukup. *See* 37 C.F.R. § 42.108(a).

III. CONCLUSION

Based on the arguments presented in the Petition, we conclude that Petitioner has demonstrated a reasonable likelihood of prevailing with respect to at least one claim of the '909 patent challenged in the Petition. Accordingly, we institute a trial on all remaining challenged claims (i.e., claims 5, 6, and 9–20) and all grounds asserted with respect to those claims in the Petition. The Board has not made a final determination under 35 U.S.C. § 318(a) with respect to the patentability of the challenged claims.

IV. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that, pursuant to 35 U.S.C. § 314(a), an *inter partes* review of claims 5, 6, and 9–20 of the '909 patent is instituted with respect to all grounds set forth with respect to those claims in the Petition; and

FURTHER ORDERED that, pursuant to 35 U.S.C. § 314(c) and 37 C.F.R. § 42.4(b), *inter partes* review of the '909 patent shall commence on the entry date of this Decision, and notice is hereby given of the institution of a trial.

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