

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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WESTERN DIGITAL TECHNOLOGIES, INC.,  
Petitioner,

v.

GODO KAISHA IP BRIDGE 1,  
Patent Owner.

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IPR2024-01384  
Patent 7,884,403 B2

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Before SHEILA F. McSHANE, MONICA S. ULLAGADDI, and  
JOHN D. HAMANN, *Administrative Patent Judges*.

Opinion for the Board filed by *Administrative Patent Judge* McSHANE.

Opinion Dissenting filed by *Administrative Patent Judge* HAMANN.

McSHANE, *Administrative Patent Judge*.

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

## I. INTRODUCTION

Western Digital Technologies, Inc. (“Petitioner”) filed a Petition for *inter partes* review of claims 1–8 of U.S. Patent No. 7,884,403 B2 (Ex. 1001, “the ’403 patent”), along with the Declaration of Jeffrey Bokor, Ph.D. Paper 1 (“Pet.”); Ex. 1024. Godo Kaisha IP Bridge (“Patent Owner”) filed a Preliminary Response. Paper 8 (“Prelim. Resp.”).

Institution of an *inter partes* review is authorized by statute when “the information presented in the petition . . . and any 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.” 35 U.S.C. § 314(a) (2018). Upon consideration of the Petition, the Preliminary Response, and the evidence of record, we determine that Petitioner has not established a reasonable likelihood of prevailing with respect to the unpatentability of at least one claim of the ’403 patent. Accordingly, for the reasons that follow, we decline to institute an *inter partes* review of claims 1–8 of the ’403 patent.

### A. Related Matters

Petitioner indicates the ’403 patent is the subject of the district court litigations *Godo Kaisha IP Bridge I v. Western Digital Technologies, Inc.*, 3:24-cv-06555-RS (N.D. Cal.); and *Godo Kaisha IP Bridge I v. Seagate Technology LLC*, No. 24-cv-3691 (D. Minn.), both transferred from the District of Delaware. Paper 9, 2; Paper 6, 1.

### B. The ’403 Patent

The ’403 patent is titled “Magnetic Tunnel Junction Device and Memory Device Including the Same,” and issued on February 8, 2011,

claiming priority to a PCT application filed March 10, 2005. Ex. 1001 codes (22), (45), (54). The '403 patent also claims priority from Japanese Application Nos. 2004-071186 and 2004-313350, filed March 12, 2004, and October 28, 2004, respectively. *Id.* at code (30).

The Specification of the '403 patent states that it “relates to a magnetic tunnel junction [‘MTJ’] device and a method of manufacturing the same, particularly to a magnetic tunnel junction device with a high magnetoresistance.” Ex. 1001, 1:9–12. The '403 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 DRAM memories.” *Id.* at 1:14–17. 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 1:25–29. An objective of the patent is “to increase the output voltage of a MTJ device.” *Id.* at 2:18–19.

According to the '403 patent, “the MTJ device structure of the present embodiment comprises a first Fe (001) layer 1, a second Fe (001) layer 5, and a single-crystalline  $\text{MgO}_x$  (001) layer 3 or a poly-crystalline  $\text{MgO}_x$  ( $0 < x < 1$ ) layer 3 sandwiched there between, the polycrystalline layer having the (001) crystal plane preferentially oriented therein.” Ex. 1001, 5:19–24. 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 6:59–63. “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.” *Id.* at 6:60–63. The ’403 patent notes that the “aforementioned tunnel barrier height  $\phi$  was determined by fitting the electric conductance characteristics of the MTJ device (the relationship between tunnel current density  $J$  and bias voltage  $V$ ) onto the Simmons’ formula [cite omitted] based on the WKB approximation, using the least squares method.” *Id.* at 7:3–9.

*C. Illustrative Claim*

Petitioner challenges claims 1–8 of the ’403 patent. Claims 1, 5, 6, 7, and 8 are the independent claims. Claim 1 is representative and is reproduced below, with bracketed letters added to limitations for reference purposes.

1[pre] A magnetoresistive device having a tunnel barrier junction structure, the magnetoresistive device comprising:

1[a] a tunnel barrier layer;

1[b] a first ferromagnetic material layer of a BCC structure;  
and

1[c] a second ferromagnetic material layer of a BCC structure; and

1[d] said tunnel barrier layer is formed by a single-crystalline  $\text{MgO}_x$  (0< $x$ <1) or a poly-crystalline  $\text{MgO}_x$  (0< $x$ <1) in which (001) crystal plane is preferentially oriented, and

1[e] wherein a tunnel barrier height between a bottom of a conduction band of said tunnel barrier layer and a Fermi energy of at least one of said first and second ferromagnetic layers is a discontinuous value in a range of 0.2 to 0.5 eV.

Ex. 1001, 9:26–42.

*D. Asserted Grounds of Unpatentability*

Petitioner asserts that claims 1–8 are unpatentable based on the following grounds:

| <b>Claim(s)<br/>Challenged</b> | <b>35 U.S.C §</b>   | <b>Reference(s)/Basis</b>               |
|--------------------------------|---------------------|-----------------------------------------|
| 1, 2, 5                        | 103(a) <sup>1</sup> | Bowen, <sup>2</sup> Soukup <sup>3</sup> |
| 1–8                            | 103(a)              | Bowen, Soukup, Sunai <sup>4</sup>       |
| 1–3, 5–8                       | 103(a)              | Nagahama, <sup>5</sup> Soukup           |
| 1–8                            | 103(a)              | Nagahama, Soukup,<br>Sunai              |

Pet. 26.

II. ANALYSIS

*A. Level of Ordinary Skill in the Art*

Relying on the testimony of Dr. Bokor, Petitioner proposes that a person of ordinary skill in the art at the time of the '403 patent would have

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<sup>1</sup> The Leahy-Smith America Invents Act, Pub. L. No. 112-29, 125 Stat. 284 (2011) (“AIA”), amended 35 U.S.C. § 103, and was effective on March 16, 2013. Because the '403 patent has an effective filing date prior to the effective date of the applicable AIA amendments, we refer to the pre-AIA version of 35 U.S.C. § 103.

<sup>2</sup> M. Bowen, “Large magnetoresistance in Fe/MgO/FeCo(001) epitaxial tunnel junctions on GaAs(001),” Appl. Phys. Lett., Vol. 79, No. 11, 1655–1657 (2001) (Ex. 1026, “Bowen”).

<sup>3</sup> R. J. Soukup, “Voltage-Current Characteristics for Electrical Conduction Through Thin MgO Films,” J. Appl. Phys., Vol. 41, No. 8, 3229–3236 (1970) (Ex. 1029, “Soukup”).

<sup>4</sup> JP 2002/204004 A, published July 19, 2002 (Ex. 1030, “Sunai”) (certified translation of original in Ex. 1029).

<sup>5</sup> Nagahama, WO 2002-099905, published Feb. 25, 2004 (Ex. 1027, “Nagahama”).

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.” Pet. 29 (citing Ex. 1024 ¶ 25).

Patent Owner “does not challenge Petitioner’s POSA [person of ordinary skill in the art] definition.” Prelim. Resp. 17.

In determining the level of ordinary skill in the art, various factors may be considered, including the “type of problems encountered in the art; prior art solutions to those problems; rapidity with which innovations are made; sophistication of the technology; and educational level of active workers in the field.” *In re GPAC Inc.*, 57 F.3d 1573, 1579 (Fed. Cir. 1995) (citation omitted). The level of ordinary skill in the art is also reflected by the prior art of record. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001). For purposes of this Decision, we adopt the assessment offered by Petitioner, as it is consistent with the ’403 patent and the asserted prior art.

### *B. Claim Construction*

In this *inter partes* review, claims are construed using the same claim construction standard that would be used to construe the claims in a civil action under 35 U.S.C. § 282(b). 37 C.F.R. § 42.100(b) (2021). Under the principles set forth by our reviewing court, the “words of a claim ‘are generally given their ordinary and customary meaning,’” as would be understood by a person of ordinary skill in the art in question at the time of

the invention. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312 (Fed. Cir. 2005) (en banc) (quoting *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996)). “In determining the meaning of the disputed claim limitation, we look principally to the intrinsic evidence of record, examining the claim language itself, the written description, and the prosecution history, if in evidence.” *DePuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.*, 469 F.3d 1005, 1014 (Fed. Cir. 2006) (citing *Phillips*, 415 F.3d at 1312–17).

Petitioner “submits the claim terms should be given their plain and ordinary meaning and no claim construction is necessary to find the claims unpatentable.” Pet. 26. Patent Owner does not address claim construction in its Preliminary Response. *See generally* Prelim. Resp.

We determine that we need not expressly construe any claim terms to resolve the parties’ disputes on the current record. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (“[W]e need only construe terms ‘that are in controversy, and only 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))).

### *C. Principles of Law*

A patent claim is unpatentable under 35 U.S.C. § 103(a) if “the differences between 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 to a person having ordinary skill in the art to which said subject matter pertains.” 35 U.S.C. § 103 (2011); *see also KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations including (1) the

scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) when in evidence, objective indicia of nonobviousness.<sup>6</sup> *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

*D. Asserted Obviousness of Claims 1–8 over Bowen and Soukup, With or Without Sunai*

Petitioner contends that claims 1, 2, and 5 are unpatentable under 35 U.S.C. § 103(a) as obvious over the combination of Bowen and Soukup, with or without Sunai, and also contends that claims 3, 4 and 6–8 are unpatentable under 35 U.S.C. § 103(a) as obvious over the combination of Bowen, Soukup, and Sunai. Pet. 26, 30–53. In support, Petitioner relies upon the Bokor Declaration. Ex. 1024. Patent Owner argues that the combination of Bowen, Soukup, and Sunai does not teach or suggest all the limitations of claim 1 and that Petitioner’s rationale for the combination of Bowen and Soukup is deficient. Prelim. Resp. 18–63.

We begin our discussion with brief summaries of Bowen, Soukup, and Sunai and then address the evidence and arguments presented.

*1. Bowen (Ex. 1026)*

Bowen describes that “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 “presents tunneling experiments on Fe(001)/MgO(20 Å)/FeCo(001) single-

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<sup>6</sup> No evidence of objective indicia of nonobviousness is presented in Patent Owner’s Preliminary Response. *See generally* Prelim. Resp.

crystal epitaxial junctions of high quality grown by sputtering and laser ablation.” *Id.*, Abstract.

Bowen discloses that “numerical calculations of spin-dependent tunneling and TMR [tunneling magnetoresistance] have been developed for single crystal MTJs such as Co/Al<sub>2</sub>O<sub>3</sub>/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. 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.* (footnotes omitted).

Tests were performed on a single-crystal epitaxially grown structures in a Fe(001)/MgO(001)/FeCo(001) tunnel junction. Ex. 1026, 1655. With a MgO barrier layer of 20 Å thickness (*id.*), 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 (Ex. 1028)

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

“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.*, Abstract.

### 3. *Sunai (Ex. 1030)*

Sunai is directed to “a magnetoresistance effect element, magnetic memory, magnetic head, and magnetic reproducing device that can maintain a sufficiently high magnetoresistance ratio and prevent an increase in the reversal magnetic field even when the size is reduced.” Ex. 1030, Abstract.

Sunai explains that when using this type of device in solid-state magnetic random access memory (MRAM), “MRAM has a problem in that when the size of the memory cell is reduced to increase the capacity, the magnetic field required to reverse the magnetization direction of the free layer, the so-called reversal magnetic field, becomes larger, and a larger write current is required.” Ex. 1030 ¶¶ 4–5. Sunai further explains, “in the prior art, when the size of the memory cell is reduced, it is not possible to prevent an increase in the reversal magnetic field of the free layer while maintaining a sufficiently high magnetoresistance ratio.” *Id.* ¶ 9.

Sunai discloses:

In order to solve the above problem, the present invention provides a magnetoresistance effect element comprising a first ferromagnetic layer that maintains the direction of magnetization when a predetermined external magnetic field is not applied, a

second ferromagnetic layer that can change the direction of magnetization when the external magnetic field is not applied, and a first tunnel barrier layer interposed between the first ferromagnetic layer and the second ferromagnetic layer, wherein the first ferromagnetic layer, the first tunnel barrier layer, and the second ferromagnetic layer form a ferromagnetic tunnel junction, and wherein the composition of the ferromagnetic material contained in the second ferromagnetic layer is expressed by the general formula  $(\text{CoFe})_{100-x}\text{Y}_x$  or the general formula  $(\text{CoFeNi})_{100-x}\text{Y}_x$ , where Y is at least one element selected from the group consisting of B, Si, Zr, P, Mo, Al, and Nb.

Ex. 1030 ¶ 11.

Sunai discloses that “[i]n a normal film formation method at room temperature, the lower limit of the film thickness at which a  $\text{Co}_9\text{Fe}$  film that does not contain B can be formed as a continuous film is about 1.5 nm.” Ex. 1030 ¶ 27. But, “when B is added to  $\text{Co}_9\text{Fe}$ , a continuous film can be formed up to a film thickness of about 0.5 nm.” *Id.* ¶ 28. Sunai explains that the “reason that an extremely thin continuous film can be formed when the element Y is added is that the addition of the element Y suppresses the diffusion or movement of atoms that reach the film formation surface during the film formation process, thereby suppressing crystallization.” *Id.* ¶ 30. In contrast, in prior art structures, according to Sunai, “when the film thickness is thinned, island structures are formed in which each island has a diameter of about several nanometers, and although each island is a ferromagnetic material, it exhibits superparamagnetism, in which the magnetization direction fluctuates, resulting in a significantly low magnetoresistance change rate.” *Id.*

#### 4. Discussion

##### a. Claim 1

We determine that Petitioner has failed to meet its burden to show a reasonable likelihood of prevailing in demonstrating that the combination of Bowen and Soukup, with or without Sunai, would have rendered claim 1 obvious. This determination is based on the evidence and argument presented for limitation 1[e], which we discuss below.

Petitioner asserts that Bowen teaches the claimed magnetoresistive device having two ferromagnetic material layers with a tunnel barrier layer between them, where the tunnel barrier layer includes, at least, a single-crystal MgO(001) tunnel barrier structure. *See* Pet. 30–36.

For the teaching of limitation 1[e], “wherein a tunnel barrier height between a bottom of a conduction band of said tunnel barrier layer and a Fermi energy of at least one of said first and second ferromagnetic layers is a discontinuous value in a range of 0.2 to 0.5 eV,” Petitioner relies upon Bowen and Soukup<sup>7</sup>, asserting that the combination teaches or suggests a tunnel barrier height<sup>8</sup> for the MgO layer in the claimed range of 0.2 to 0.5 eV. Pet. 37 (citing Ex. 1024 ¶¶ 147, 148, 156–160). 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

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<sup>7</sup> Petitioner does not rely on Sunai for the teaching of limitation 1[e]. *See* Pet. 37–40.

<sup>8</sup> Petitioner asserts that “[t]he claim language ‘a tunnel barrier height between a bottom of a conduction band of said tunnel barrier layer and a Fermi energy of at least one of said first and second ferromagnetic layers is a discontinuous value’ merely recites the definition of a ‘tunnel barrier height’ in an MTJ.” Pet. 37.

‘about 0.33 eV’ for its MgO barrier.” *Id.* (emphasis omitted) (citing Ex. 1026, 1656; Ex. 1024 ¶ 148; Ex. 1028, Abstract, 3231–32, Fig. 5, Table I). Petitioner asserts that “Soukup taught that oxygen vacancy defects had an impact on the barrier height for MgO.” *Id.* (citing Ex. 1024 ¶ 149). For support, Petitioner, in part, cites to Soukup, which states:

The 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.

Petitioner argues that one 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. 38 (citing Ex. 1028, Abstract, 3232, 3236; Ex. 1024 ¶ 150). Petitioner asserts that “[a]ccording to the equation for the TMR,<sup>[9]</sup> lowering the resistance (barrier height) for parallel electrons ( $R_p$ ) would increase TMR.” *Id.* (Ex. 1035, 3273; Ex. 1027 ¶ 2; Ex. 1001, 4:43–52; Ex. 1024 ¶ 150). Petitioner contends that “TMR is 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. 1055, 2271; Ex. 1024 ¶ 151; Ex. 1026, Abstract, 1655).

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<sup>9</sup> A mathematical equation for TMR is:

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

In this equation, “ $R_{ap}$ ” is the antiparallel resistance and “ $R_p$ ” is the parallel resistance in an MRAM. *See* Ex. 1035, 3273.

Petitioner further argues that “Butler<sup>10</sup> and Mathon<sup>11</sup> taught that MgO barriers would achieve higher TMRs due to improved symmetry matching between the MgO barrier and ferromagnetic electrodes, facilitating tunneling of parallel electrons across the barrier compared to antiparallel tunneling.” Pet. 38 (citing Ex. 1044, 1; Ex. 1046, 1; Ex. 1024 ¶ 151). Petitioner contends that a 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 heights.” *Id.* at 38–39 (citing Ex. 1024 ¶ 147).

Petitioner also asserts that the claimed tunnel barrier height range of 0.2 to 0.5 eV would have been obvious. Pet. 39 (citing Ex. 1024 ¶ 154). Petitioner 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 they observed, which was ‘lower than half of the calculated value for ‘an ultrathin layer’ of MgO, [was] due to the ‘presence of stoichiometric . . . inhomogeneities in the insulating film.’” *Id.* at 39–40 (citing Ex. 1026, 1656; Ex. 1024 ¶ 154). Petitioner also refers to Soukup, alleging that it Soukup “observed a relationship between barrier height and MgO stoichiometry.” *Id.* at 40 (citing Ex. 1028, 3232, 3236). Petitioner argues that “one of skill would have been motivated to adjust

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<sup>10</sup> W.H. Butler, “Spin-dependent tunneling conductance of Fe/MgO/Fe sandwiches,” *Phys. Rev. B*, Vol. 63, 054416 (2001).

<sup>11</sup> J. Mathon, “Theory of tunneling magnetoresistance of an epitaxial Fe/MgO/Fe(001) junction,” *Phys. Rev. B*, Vol. 63, 220403(R) (2001).

oxygen vacancy defects to increase TMR by lowering the barrier height as taught by Soukup.” *Id.*

Petitioner additionally refers to the disclosure in the ’403 patent that states 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 . . . 0.2 to 0.5 eV), which is thought to result in an increase in the tunneling current.” Pet. 40 (quoting Ex. 1001, 6:52–56). Petitioner argues that “according to the ’403 Patent, 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; Ex. 1024 ¶ 155). Petitioner also argues that, in the co-pending litigation, Patent Owner asserted that the limitation was satisfied by the mere “presence of oxygen vacancy defects.” *Id.* (citing Ex. 1065, 20; 22 (citing Ex. 1001, 6:47–7:2); Ex. 1001, 6:47–7:2).

We agree with Patent Owner that the arguments and evidence presented in the Petition are insufficient to show that the combination of Bowen, Soukup, and Sunai teaches or suggests limitation 1[e] or that a person of ordinary skill in the art would have been motivated to combine the references’ teachings. *See* Prelim. Resp. 18–63.

First, we note that Petitioner identifies a paper by Simmons (Ex. 1031), which, according to Petitioner, “describe[es] the ‘tunnel effect’ of electrons across the barrier using *quantum mechanics* and providing a mathematical formula to estimate the barrier height.” Pet. 8–10 (emphasis added); *see also* Ex. 1024 ¶¶ 45–49 (discussing Simmons and quantum tunneling). Petitioner does not, however, specifically address the methods that are applied in Soukup to determine the “apparent barrier height[s],”

which are the Arrhenius plot and zero-field intercept, or why Petitioner chose to select data from the Arrhenius plot method, as discussed below. *See generally* Pet.; Ex. 1028, 3229 (Abstract).

Soukup is directed to determining “the voltage-current characteristics of Au–MgO–Au thin-film emission diodes,” where different samples were tested under different conditions. Ex. 1028, 3229 (Abstract). Although Soukup refers to Simmons, the data that Petitioner relies upon for the apparent barrier height of its MgO layer (Pet. 37 (“about 0.33 eV”)) is that determined *using the slope of an Arrhenius plot*. Ex. 1028, Abstract, 3231–3232, Fig. 5, Table I. In Soukup, apparent barrier heights for the samples were also determined using the zero-field intercept of the straight line  $\log I$  versus  $V^{1/2}$  plot. *Id.*, Abstract, 3230–3232, Fig. 3, Table I. Reproduced below is Table I of Soukup, as annotated by Patent Owner. *See* Ex. 1028, 3233; Prelim. Resp. 38.

TABLE I. Summary of device data.

| Device No. | $S^a$ | $S_0^b$ | $\varphi_1^c$          | $\varphi_2^d$ | $P_{O_2}^e$     |
|------------|-------|---------|------------------------|---------------|-----------------|
| 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 <sup>f</sup> | ...           | $10^{-5}$ , ... |

<sup>a</sup>  $S$  = oxide thickness, in Å.

<sup>b</sup>  $S_0$  = overlayer thickness, in Å.

<sup>c</sup>  $\varphi_1$  = barrier obtained by zero intercept method, in eV.

<sup>d</sup>  $\varphi_2$  = barrier obtained from slope of Arrhenius plot, in eV.

<sup>e</sup>  $P_{O_2}$  = pressure of admitted  $O_2$  during MgO deposition, in Torr.

<sup>f</sup> The barrier was obtained from the slope of the Fowler-Nordheim plot.

Annotated Table I of Soukup includes the results of analyses of sample test data, with the column highlighted in yellow showing the barrier heights obtained by a zero-field intercept method, the column highlighted in blue 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; Prelim. Resp. 38. Table I reflects that, based on the method used to analyze the data, different apparent barrier heights were calculated, with very different ranges in values for those determined by analysis by Arrhenius plots or zero-field intercept plots, respectively. In fact, there is no overlap of the apparent barrier height values determined by the different methods.<sup>12</sup>

Petitioner picks one of Soukup's calculated values determined by the Arrhenius plot, but does not explain why this value is one that would be representative for an magnetoresistive device.<sup>13</sup> Pet. 37; Ex. 1024 ¶ 148. Put another way, Petitioner and its declarant, Dr. Bokor, do not explain or provide any supporting evidence why a person of ordinary skill would have selected the barrier height value of Soukup determined by an Arrhenius plot.

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<sup>12</sup> We note that the values determined by the zero-field intercept method are completely outside of the claimed tunnel barrier height range of 0.2 to 0.5 eV. Ex. 1028, 3233.

<sup>13</sup> As Soukup itself recognizes, certain transport mechanisms were determined to be controlling (or not) based upon certain specific mathematical analysis of the sample test data. *See* Ex. 1028, 3230–3232 (assessing whether an emission was by Schottky mechanisms, rather than by a Poole-Frenkel effect, for instance, based on certain mathematical analyses of the data). This indicates that Soukup recognizes that certain mathematical analyses are more applicable to certain transport mechanisms.

Moreover, the '403 patent states that a tunnel barrier height of approximately 0.3 eV was determined by “fitting the electric conductance characteristics of the MTJ device (the relationship between tunnel current density  $J$  and bias voltage  $V$ ) onto the Simmons’ formula (Equation (20)).” Ex. 1001, 7:3–9. Here, Petitioner relies on a value derived from a different analysis method, the Arrhenius plot, not the Simmons formula. *See* Pet. 37; Ex. 1028, Table I.

Additionally, the value of the apparent barrier height of Soukup selected by Petitioner as the relevant teaching is not accurate and appears to be a higher value. Soukup states, in reference to Arrhenius plots, including that for the device with the relied-upon 0.33 eV apparent barrier height, that “the slope of the  $\ln(I_0/T^2)$  vs  $1/T$  plots *will give a number which is smaller than the actual barrier*” “if the barrier increases with increasing temperature.” Ex. 1028, 3234 (emphasis added); *see also id.*, Fig. 5, Fig. 11, Table I. Petitioner does not address this issue, and more specifically, does not provide any evidence to support that the barrier height in Soukup would not increase with temperature.

On the point of whether barrier heights increase with increasing temperature, Patent Owner refers to the Soukup dissertation (Ex. 2007) which Patent Owner argues provides more information on Soukup’s research. Prelim. Resp. 40–44. Patent Owner asserts that the Soukup dissertation has a publication date that is earlier than the priority date for the '403 patent and the dissertation was cataloged and accessed from the University of Minnesota library at least as early as November 9, 1987. *Id.* at 41 (citing Ex. 2008 ¶¶ 63, 34–62 (with Attachments)). Patent Owner contends that Soukup (Ex. 1028) and the Soukup dissertation (Ex. 2007)

discuss the same research work, referring to the evidence presented in the respective documents, including the use of the same figures. Prelim. Resp. 42–43. We have reviewed this evidence and find that it provides support that the Soukup dissertation was publicly available before the priority date of the '403 patent. We have also reviewed the evidence identified in support of the allegation that Soukup and the Soukup dissertation concern the same research, and more specifically, the evidence reflecting the samples and test results in Soukup (Table I) and the Soukup dissertation (Table IV) and the same associated figures. We agree that this evidence provides support for Patent Owner's contention that Soukup and the Soukup dissertation discuss the same research work, including testing of the same samples using the same manner of analysis. *See Ariosa Diagnostics v. Verinata Health, Inc.*, 805 F.3d 1359, 1365 (Fed. Cir. 2015) (“Art can legitimately serve to document the knowledge that skilled artisans would bring to bear in reading the prior art identified as producing obviousness.”).

The Soukup dissertation presents testing results related to barrier heights as a function of temperature, including data for the device with the relied-upon 0.33 eV apparent barrier height (PY-G-11(1)). *See* Ex. 2007, 88–89, Fig. 40. The results of this testing indicate that “*barrier heights do increase with increasing temperature. Thus, the slope of the Arrhenius plot will give a value for the barrier height which is actually less than the real barrier height, as seen in these experiments.*” *Id.* at 89 (emphasis added). Accordingly, this evidence provides support that the “real” barrier height will be higher than the values determined from Arrhenius plots, including the relied-upon barrier height of 0.33 eV.

As discussed above, Petitioner fails to explain why one of ordinary skill in the art would have selected the barrier height value it relies upon. And given the disparity of Soukup's barrier tunnel values under the different methods of analyses, the reference is, at best, ambiguous as to which values are accurately representative of barrier height. Additionally, the evidence supports that the apparent barrier height value that Petitioner relies upon ("about 0.33 eV") will be a different higher value, so the actual value of the barrier height is uncertain. Accordingly, we do not find that Petitioner has met its burden to sufficiently demonstrate that a person of ordinary skill in the art would have understood Soukup to teach or suggest the claimed range of limitation 1[e] in that there is insufficient evidence presented that supports that the selected Soukup barrier height value represents an accurate value.

Second, we disagree with Petitioner that limitation 1[e] is "inherent when there are oxygen vacancy defects as disclosed by both Bowen and Soukup" and "satisfied by the mere 'presence of oxygen vacancy defects.'" *See* Pet. 40. Petitioner cites as support a sentence in the '403 patent mentioning the claimed 0.2–0.5 eV range and a claim chart attached to Patent Owner's complaint in the district court case. *Id.* (citing Ex. 1001, 6:47–7:2; Ex. 1064, 20).

Neither, however, shows that a tunnel barrier height of 0.2–0.5 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.’’). The full sentence in the ’403 patent reads: “When 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. 1001, 6:52–56. The fact that the ’403 patent describes a broader range of 0.10–0.85 eV that includes values *outside* the claimed range of 0.2–0.5 eV shows that the claimed range is not necessarily achieved when oxygen vacancy defects are present. *See* Prelim. Resp. 59.

Bowen also contradicts Petitioner’s position. Petitioner argues that Bowen’s MgO barrier layer has “oxygen vacancy defects” and “[o]xygen vacancies are naturally present in every oxide,” but Bowen discloses a barrier height of 0.9 eV, which is *outside* the claimed range. Pet. 37. Thus, the ’403 patent and Bowen both contradict Petitioner’s assertion that a barrier height within the claimed range of 0.2–0.5 eV is inherent when there are oxygen vacancy defects.

Third, Petitioner has not shown sufficiently that a person of ordinary skill in the art would have been motivated to combine the teachings of Bowen and Soukup. Petitioner acknowledges that Bowen teaches a barrier height (0.9 eV) outside the claimed range (0.2–0.5 eV), but contends that an ordinarily skilled artisan “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.”<sup>14</sup> Pet. 37–38. Petitioner asserts that Soukup teaches or suggests a specific relationship between the amount of oxygen vacancy defects in the barrier layer and the barrier height, namely that “a higher level of oxygen vacancy defects lowered the barrier height.” *Id.* at 38; *see* Ex. 1024 ¶ 149 (Dr. Bokor similarly testifying that “Soukup taught there was an inverse correlation between oxygen vacancy defects and the barrier height of the MgO layer”). As support for that conclusion, Petitioner relies on the following sentence in Soukup: “The 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. 37–38. That sentence, however, expressly pertains to the “zero-field intercept” method of determining barrier height—not the Arrhenius plot method by which Soukup’s “about 0.33 eV” barrier height was determined, which Petitioner

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<sup>14</sup> As explained above, Petitioner relies on the combined teachings of Bowen and Soukup for the teaching of limitation 1[e]. *See* Pet. 38 (arguing that a person of ordinary skill in the art would have been motivated to “apply” Soukup’s alleged teaching of a barrier height of “about 0.33 eV”), 39 (arguing that a person of ordinary skill in the art would have been motivated to “achieve Soukup’s barrier height” in Bowen’s device); 40 (“one of skill would have been motivated to adjust oxygen vacancy barriers [in Bowen] to improve TMR by lowering the barrier height as taught by Soukup.”). Accordingly, that is the combination that we assess to determine whether there is rationale for the combination in the view of an ordinarily skilled artisan. *See In re Magnum Oil Tools Int’l, Ltd.*, 829 F.3d 1364, 1381 (Fed. Cir. 2016) (“[T]he Board must base its decision on arguments that were advanced by a party, and to which the opposing party was given a chance to respond.”). Further, we do not discern that Petitioner asserts a result-effective variable theory for the teaching of limitation 1[e]. *See* Pet. 37–40.

relies on for its obviousness combination. *See* Ex. 1028, 3229 (“These 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.”), 3232.

Importantly, Soukup indicates a *different* relationship between the amount of oxygen vacancy defects in the barrier layer and the barrier height, *depending on which method is used*. Specifically, Soukup explicitly found that “[t]he apparent barrier height determined from the zero-field intercept *went up* for increasing oxygen pressure [(i.e., less oxygen vacancy defects)] and the barrier height determined from the Arrhenius plot *went down*.” Ex. 1028, 3229 (Abstract) (emphasis added).<sup>15</sup> That disclosure is reflected in Table I, where Soukup shows the results for three fabricated samples with increasing oxygen pressure during MgO deposition. *Id.* at 3233. Patent Owner provides another annotated version of Table I below (Prelim. Resp. 45):

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<sup>15</sup> Soukup’s conclusion appears to refer to the trend of the respective increasing or decreasing barrier heights values under the two different mathematical analyses methods.

TABLE I. Summary of device data.

| Device No. | $S^a$ | $S_0^b$ | $\phi_1^c$             | $\phi_2^d$ | $P_{O_2}^e$     |
|------------|-------|---------|------------------------|------------|-----------------|
| 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 <sup>f</sup> | ...        | $10^{-5}$ , ... |

zero intercept  
MgO barrier height *decreases* as oxygen vacancies increase

Arrhenius plot  
MgO barrier height *increases* as oxygen vacancies increase

<sup>a</sup>  $S$  = oxide thickness, in Å.  
<sup>b</sup>  $S_0$  = overlayer thickness, in Å.  
<sup>c</sup>  $\phi_1$  = barrier obtained by zero intercept method, in eV.  
<sup>d</sup>  $\phi_2$  = barrier obtained from slope of Arrhenius plot, in eV.  
<sup>e</sup>  $P_{O_2}$  = pressure of admitted  $O_2$  during MgO deposition, in Torr.  
<sup>f</sup> The barrier was obtained from the slope of the Fowler-Nordheim plot.

Annotated Table I above shows (in red) that 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) using the zero-field intercept method, and shows (in blue) that the barrier height *increases* as oxygen vacancies increase (i.e., as the oxygen pressure admitted during MgO deposition decreases) using the Arrhenius plot method. Prelim. Resp. 45. In other words, Petitioner’s alleged inverse relationship is present for the zero-field intercept method, but not for the Arrhenius plot method. *See id.*; Pet. 37–38. “The barrier height cannot both increase and decrease with more oxygen vacancy defects,” and Petitioner does not attempt to reconcile or explain Soukup’s disparate teachings. *See* Prelim. Resp. 45 (emphasis omitted).

We agree with Patent Owner that Petitioner is inconsistent in relying on one method as allegedly teaching a barrier height within the claimed range, while at the same time relying on the other method for a motivation under its obviousness theory. Prelim. Resp. 45–49. If a person of ordinary

skill in the art would have understood that the Arrhenius plot method was the appropriate method for determining barrier height, as Petitioner argues in asserting that Soukup teaches a barrier height of 0.33 eV, that person would have understood that “the barrier height *increases* as oxygen vacancies increase” (in blue above), and Petitioner’s obviousness theory of adding oxygen vacancies to lower Bowen’s barrier height is incorrect. *See id.* at 47. If, however, a person of ordinary skill in the art would have looked to the zero-field intercept method, that person “would have understood that *all* of Soukup’s tested samples . . . had barrier heights” (in yellow above) “above the claimed range of 0.2–0.5 eV.” *See id.* at 48. Petitioner cannot have it both ways.

Based on the record before us, Petitioner has not shown sufficiently that the combination of Bowen and Soukup teaches or suggests limitation 1[e] reciting a “tunnel barrier layer has a tunnel barrier height  $\phi$  in a range of 0.2 to 0.5 eV,” or that a person of ordinary skill in the art would have been motivated to modify Bowen, based on the teachings of Soukup, to achieve the claimed range. Accordingly, Petitioner has not shown a reasonable likelihood of prevailing on its assertion that claim 1 is unpatentable over Bowen, Soukup, with or without Sunai.

*b. Independent Claims 5–8*

Claims 5–8 recite similar limitations to limitation 1[e]. *See* Ex. 1001, 10:9–10 (claim 5: “wherein said magnesium oxide has a tunnel barrier height in a range of 0.2 to 0.5 eV”), 10:22–23 (claim 6: “wherein said tunnel barrier layer has a tunnel barrier height of 0.2 to 0.5 eV”), 10:37–38 (claim 7: “said tunnel barrier layer has a tunnel barrier height of 0.2 to 0.5 eV”), 10:53–54 (claim 8: “a tunnel barrier height of said tunnel barrier layer is in a

range of 0.2 to 0.5 eV”). For the teaching of these similar limitations, Petitioner relies upon the evidence and argument provided for limitation 1[e]. Pet. 45, 47, 48, 53. We do not find that Petitioner has shown sufficiently that the combination of Bowen and Soukup teach these limitations for the reasons discussed above for limitation 1[e]. Accordingly, Petitioner has not shown a reasonable likelihood of prevailing on its assertion that claims 5–8 are unpatentable over Bowen and Soukup, with or without Sunai.

*c. Dependent Claims 2–4*

Petitioner presents evidence and argument in support of its contentions that claims 2–4 would have been obvious over the combination of Bowen and Soukup, with or without Sunai. Pet. 41–44. Because claims 2–4 depend from claim 1 and because Petitioner’s arguments and evidence for the dependent claims do not cure the shortcomings for independent claim 1, the showing for the dependent claims is also deficient.

Accordingly, Petitioner has not demonstrated a reasonable likelihood that it would prevail in showing that the subject matter of claims 2–4 would have been obvious over the combination of Bowen and Soukup, with or without Sunai.

*E. Asserted Obviousness of Claims 1–8 over Nagahama and Soukup, With or Without Sunai*

Petitioner contends that claims 1, 2 and 5 are unpatentable under 35 U.S.C. § 103(a) as obvious over the combination of Nagahama and Soukup, with or without Sunai, and also contends that claims 3–4 and 6–8 are unpatentable under 35 U.S.C. § 103(a) as obvious over the combination

of Nagahama, Soukup, and Sunai. Pet. 26, 53–71. In support, Petitioner also relies upon the Bokor Declaration. Ex. 1024.

We begin our discussion with a brief summary of Nagahama, and then address the evidence and arguments presented.

*1. Nagahama (Ex. 1027)*

Nagahama describes a “tunnel magnetoresistance element,” where “[b]y varying only the thickness of a known material having superior magnetic characteristics to increase spin polarization without changing the chemical composition, a tunnel magnetoresistive element capable of producing a larger magnetoresistive effect is provided.” Ex. 1027, code (57). Nagahama relates to tunnel magnetoresistive elements, and particularly to a ferromagnetic tunnel magnetoresistive element outputting a large signal, a tunnel magnetoresistive element in which the dependence of the magnetoresistive effect on bias voltage is controlled, and a tunnel magnetoresistive element whose crystal orientation is set to the (001) direction of a body-centered cubic lattice, a face-centered cubic lattice, or a tetragonal lattice. *Id.* ¶ 1.

Nagahama describes that “[i]n order to achieve a magnetic sensor or ferromagnetic random access memory using this effect, a large magnetoresistive effect is required.” Ex. 1027 ¶ 3. But, Nagahama describes that “the tunnel magnetoresistive effect, first, has a problem in that it is limited by spin polarization.” *Id.* ¶ 4. Thus, “in order to obtain a high magnetoresistive effect, a material with a high spin polarization has to be used.” *Id.* ¶ 6.

Nagahama discloses a magnetoresistive element “which includes a (001)-highly-oriented lower ferromagnetic electrode layer, a (001)-highly-

oriented MgO barrier layer, and a (001)-highly-oriented upper ferromagnetic electrode layer on the MgO double underlayer.” Ex. 1027 ¶ 73. Figure 17, reproduced below, illustrates this embodiment.

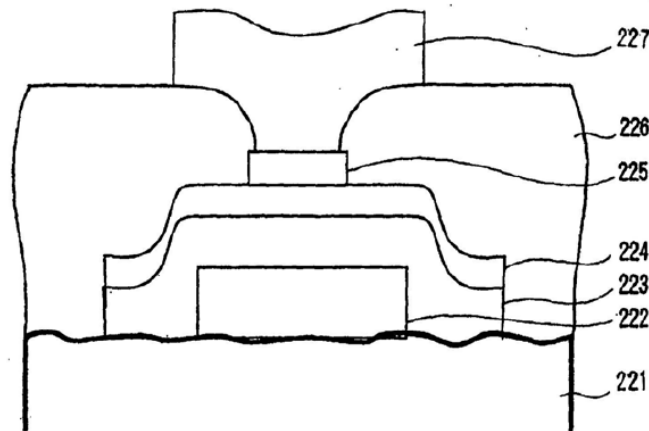


Figure 17, above, depicts “a sectional view of a high-quality tunnel magnetoresistive element having an amorphous (001)-highly-oriented MgO composite underlayer on a polycrystalline metal electrical wire with a rough surface.” Ex. 1027 ¶ 19. In Figure 17, “reference numeral 221 designates a lower electrical wire; 222, a MgO double underlayer; 223, a lower ferromagnetic electrode; 224, a barrier layer; 225, an upper ferromagnetic electrode; 226, an electrical insulating layer; and 227, an upper electrical wire.” *Id.* ¶ 76.

## 2. Discussion

### a. Claim 1

We determine that Petitioner has failed to meet its burden to show a reasonable likelihood that the combination of Bowen and Nagahama, with or without Sunai, would have rendered claim 1 obvious. This determination is based on the evidence and argument presented for limitation 1[e], which we discuss below.

Petitioner asserts that Nagahama, with and without Sunai, teaches the claimed magnetoresistive device having two ferromagnetic material layers with a tunnel barrier layer between them, where the tunnel barrier layer includes, at least, a single-crystal MgO(001) tunnel barrier structure. *See* Pet. 54–61.

For teaching limitation 1[e], “wherein the tunnel barrier layer has a tunnel barrier height  $\phi$  in a range of 0.2 to 0.5 eV,” Petitioner relies upon Nagahama and Soukup<sup>16</sup>, asserting that the combination teaches or suggests a tunnel barrier height for the MgO layer in the claimed range of 0.2 to 0.5 eV. Pet. 62–64 (citing Ex. 1024 ¶¶ 48, 255–256). Petitioner contends that Nagahama teaches a MgO MTJ, and “Soukup observed a ‘barrier height’ of ‘*about 0.33 eV*’ for its MgO barrier.” *Id.* at 62 (citing Ex. 1028, Abstract, 3231–3232, Fig. 5, Table I; Ex. 1024 ¶ 257). Petitioner asserts that, as explained for the combination with Bowen, “one of skill reading Soukup understands there was a relationship between oxygen vacancy defects and barrier height.” *Id.* (citing Ex. 1024 ¶ 258; Pet. § VI.A.6).

Petitioner argues that one 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 Nagahama’s MgO barrier.” Pet. 62 (citing Ex. 1028, Abstract, 3232, 3236; Ex. 1024 ¶ 259). Petitioner contends that “TMR is an ‘important parameter’ for improving MRAM performance” and “lowering the resistance (barrier height) for parallel electrons would improve TMR.” *Id.* (citing Ex. 1055, 2269, 2271; Ex. 1035, 3273; Ex. 1024

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<sup>16</sup> Petitioner does not rely on Sunai for the teaching of limitation 1[e]. *See* Pet. 62–64.

¶¶ 260–262; Ex. 1027 ¶ 2; Pet. § IV.A.6). Petitioner argues that Nagahama’s stated goal was to increase TMR in its device, and “Nagahama sought to increase TMR by modifying properties of the MgO barrier layer.” *Id.* at 62–63 (Ex. 1027 ¶¶ 6, 15–17; Ex. 1024 ¶ 261).

Petitioner refers to Butler and Mathon that are alleged to teach “that MgO barriers improved TMRs due to improved symmetry, facilitating tunneling of parallel electrons, and would have been motivated to explore lower barrier heights to accomplish that.” Pet. 63 (citing Ex. 1044, 1; Ex. 1046, 1; Ex. 1024 ¶¶ 259–260; Pet. § VI.A.6). Petitioner contends that a skilled artisan “seeking to improve Nagahama’s MgO MTJ would have looked to Soukup’s teachings about how defects lowered the MgO barrier height.” *Id.* (citing Ex. 1024 ¶¶ 259, 265).

Petitioner also asserts that for the same reasons explained for Bowen, the claimed barrier height range would have also been obvious. Pet. 64 (citing Pet. § VI.A.6; Ex. 1028, 3232, 3236; Ex. 1043, 1; Ex. 1045, 7; Ex. 1047, 510–511; Ex. 1051, 1; Ex. 1026, 1656; Ex. 1053, 8042–43; Ex. 1024 ¶ 267). Petitioner further argues that “this limitation is inherent when there are oxygen vacancy defects” and in the co-pending litigation, Patent Owner asserted that the limitation was satisfied by the mere “presence of oxygen vacancy defects.” *Id.* (citing Pet. § VI.A.6; Ex. 1064, 17, 19 (citing Ex. 1001, 6:47–7:2); Ex. 1024 ¶ 269).

We agree with Patent Owner that the arguments and evidence presented in the Petition are insufficient to show that the combination of Nagahama, Soukup, and Sunai teaches or suggests limitation 1[e] or that a person of ordinary skill in the art would have been motivated to combine the references’ teachings. *See* Prelim. Resp. 63–67. As Patent Owner argues,

and we agree, Nagahama does not disclose the device's tunnel barrier height, and Petitioner relies on the same Soukup reference used with Bowen to meet the tunnel barrier height limitation. *Id.* at 65–66. We also agree with Patent Owner that Petitioner's arguments on Nagahama largely track those presented for the ground with Bowen *Id.* at 63–65.

Similar to the ground based upon Bowen, for this ground the evidence presented in the Petition is not sufficient to support that barrier height value of 0.33 eV of Soukup selected by Petitioner represents an accurate or representative value for the reasons discussed above in the Bowen ground. Petitioner also has not shown sufficiently that a person of ordinary skill in the art would have been motivated to combine the teachings of Nagahama and Soukup. Similar to Bowen, Nagahama does not teach the claimed barrier height, and, although Petitioner asserts that a person of skill would have looked to Soukup's teachings about MgO barriers and how defects lowered the barrier height, the Soukup evidence instead indicates otherwise. As discussed above, for the relied-upon Soukup barrier height value determined by Arrhenius plot, the barrier height instead went down with increasing oxygen pressure, that is, with less oxygen vacancy defects. Accordingly, as explained above, a person of skill would have understood that the barrier height increases as oxygen vacancies increase for the Arrhenius plot method data, and this is contrary to Petitioner's obviousness theory of adding oxygen vacancies to lower Nagahama's barrier height. Further, we do not agree with Petitioner's arguments related to inherency for the reason included in the Bowen ground: the '403 patent discloses barrier heights outside of the claimed range, which contradicts Petitioner's assertion that a barrier height within the claimed range of 0.2–0.5 eV is inherent.

Based on the record before us, Petitioner has not shown sufficiently that the combination of Nagahama and Soukup teaches or suggests limitation 1[e] or that a person of ordinary skill in the art would have been motivated to modify Nagahama, based on the teachings of Soukup, to achieve the claimed range. Accordingly, Petitioner has not shown a reasonable likelihood of prevailing on its assertion that claim 1 is unpatentable over Nagahama and Soukup, with or without Sunai.

*b. Independent Claims 5–8*

Claims 5–8 recite similar limitations to limitation 1[e]. *See* Ex. 1001, 10:9–10 (claim 5: “wherein said magnesium oxide has a tunnel barrier height in a range of 0.2 to 0.5 eV”), 10:22–23 (claim 6: “wherein said tunnel barrier layer has a tunnel barrier height of 0.2 to 0.5 eV”), 10:37–38 (claim 7: “said tunnel barrier layer has a tunnel barrier height of 0.2 to 0.5 eV”), 10:53–54 (claim 8: “a tunnel barrier height of said tunnel barrier layer is in a range of 0.2 to 0.5 eV”). For the teaching of these similar limitations, Petitioner relies upon the evidence and argument provided for limitation 1[e]. Pet. 66, 68, 69, 71. We do not find that Petitioner has shown sufficiently that the combination of Nagahama and Soukup teach these limitations for the reasons discussed above for limitation 1[e]. Accordingly, Petitioner has not shown a reasonable likelihood of prevailing on its assertion that claims 5–8 are unpatentable over Nagahama and Soukup, with or without Sunai.

*c. Dependent Claims 2–4*

Petitioner presents evidence and argument in support of its contentions that claim 2–4 would have been obvious over the combination of Nagahama and Soukup, with or without Sunai. Pet. 64–66. Because claims

2–4 depend from claim 1 and because Petitioner’s arguments and evidence for the dependent claims do not cure the shortcomings for independent claim 1, the showing for the dependent claims is also deficient.

Accordingly, Petitioner has not demonstrated a reasonable likelihood that it would prevail in showing that the subject matter of claims 2–4 would have been obvious over the combination of Nagahama and Soukup, with or without Sunai.

#### IV. CONCLUSION

For the foregoing reasons, we conclude that the information presented in the Petition fails to establish a reasonable likelihood that Petitioner would prevail in showing that at least one claim of the ’403 patent is unpatentable. Accordingly, we do not institute *inter partes* review.

#### V. ORDER

Accordingly, it is:

ORDERED that, pursuant to 35 U.S.C. § 314(a), *inter partes* review is *denied*.

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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WESTERN DIGITAL TECHNOLOGIES, INC.,  
Petitioner,

v.

GODO KAISHA IP BRIDGE 1,  
Patent Owner.

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IPR2024-01384  
Patent 7,884,403 B2

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HAMANN, *Administrative Patent Judge*, dissenting.

I respectfully dissent from the decision denying institution. In my view, Petitioner’s challenge to at least independent claim 1 based on Bowen and Soukup meets the reasonable likelihood standard for purposes of institution. On that basis, I would institute an *inter partes* review.

I. INTRODUCTION

Below I provide a brief technology discussion to provide additional context, and I address the parties’ arguments regarding disputed issues.

*A. Technology Discussion*

The ’403 patent relates to a magnetoresistive random access memory (“MRAM”). *See* Ex. 1001, 1:8–3:43 (describing the prior art and the claimed invention). In particular, the ’403 patent focuses on a magnetic tunnel junction device (“MTJ”), which “is the most important part of the

MRAM.” *Id.* at 1:22–25. Both MRAMs and MTJs were well-known. *Id.* at 1:14–2:10 (“Description of Related Art”). Reproduced below are prior art Figures 8(A) and 8(B) from the ’403 patent which “show the structure of the MTJ device and its operating principle.” *Id.* at 4:5–6.

FIG. 8 (A)

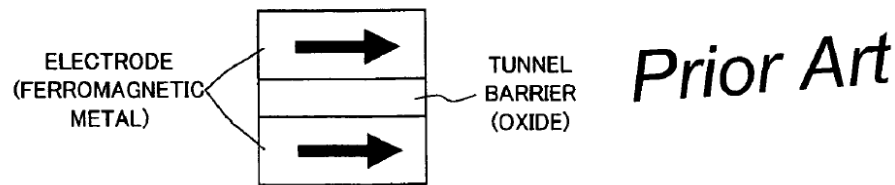


Figure 8(A) shows the structure of a MTJ. *Id.* at 1:31–33. As illustrated, a MTJ “comprises a tunnelling junction structure in which a tunnel barrier . . . made of an oxide is sandwiched between a first and a second electrode made of a ferromagnetic metal.” *Id.* at 1:25–29. This figure shows “the case of parallel magnetization alignment where the directions of magnetizations of the first and second ferromagnetic electrodes are aligned parallel, [and] the electric resistance of the device with respect to the direction normal to the interfaces of the tunneling junction structure decreases.” *Id.* at 1:31–36.

FIG. 8 (B)



Figure 8(B) shows the other case of alignment for a MTJ device. *Id.* at 1:36–41. “[I]n the [opposite] case of antiparallel magnetization alignment where the directions of magnetizations of the first and second ferromagnetic

electrodes are aligned antiparallel . . . , the electric resistance with respect to the direction normal to the interfaces of the tunneling junction structure increases.” *Id.* The ’403 patent explains that “[t]he resistance value does not change in a general state, so that information ‘1’ or ‘0’ can be stored depending on whether the resistance value is high or not.” *Id.* at 1:41–44.

In addition, a well-known formula to measure the tunneling resistance across the MTJ (i.e., the tunnel magnetoresistance ratio (“TMR”)) is the following where  $R_p$  and  $R_{ap}$  indicate the tunnel junction resistance in the cases of the parallel and antiparallel magnetization alignments, respectively:

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

*E.g.*, Ex. 1035,<sup>17</sup> 3273; Ex. 1001, 4:44–52; *see also* Ex. 1024 ¶ 37

(describing the TMR as “characteriz[ing] the effectiveness of the junction at passing parallel electrons while inhibiting antiparallel electron tunneling”).

#### *B. Combining Bowen and Soukup*

The parties dispute whether one of ordinary skill in the art would have been motivated to combine Bowen and Soukup’s teachings. I find that Petitioner makes this showing. In particular, I agree with Petitioner that in view of Bowen and Soukup’s teachings that one of ordinary skill in the art would have been motivated to lower the barrier height of the MTJ’s Magnesium Oxide (“MgO”) barrier layer to improve the performance of Bowen’s MRAM. Pet. 7, 38–39.

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<sup>17</sup> Moodera et al., *Large Magnetoresistance at Room Temperature in Ferromagnetic Thin Film Tunnel Junctions*, 74 Phys. Rev. Lett. 3273–76 (1995).

As Petitioner explains, “[s]killed artisans, including Bowen, had long been interested in increasing TMR to enable better performing MRAM.” *Id.* at 38 (citing Ex. 1026, 1655; Ex. 1055,<sup>18</sup> 2271; Ex. 1024 ¶ 151); *see also id.* at 7 (citing Ex. 1049,<sup>19</sup> 194–95; Ex. 1055, 2269; Ex. 1024 ¶¶ 41–44) (arguing that it was known that higher TMR allowed lowered power consumption, improved the signal-to-noise ratio, and paved the way for smaller, denser MRAMs). And at this stage I agree with Petitioner that TMR is increased when  $R_p$  is lowered. *See id.* at 38 (citing Ex. 1024 ¶ 150). As Dr. Bokor testifies, “[a]s is evident from the TMR equation, lowering the resistance . . . for parallel spin electrons [(i.e.,  $R_p$ )] compared to antiparallel [(i.e.,  $R_{ap}$ )] improved TMRs.” Ex. 1024 ¶ 150. I find this testimony is consistent with TMR’s equation that has  $R_p$  as its denominator. And, at this stage, I agree with Petitioner and find that  $R_p$  is lowered when the tunnel barrier height is lowered. Pet. 38. I credit Dr. Bokor’s testimony in this regard as I find it consistent with the cited support and Dr. Bokor’s testimony regarding the principles of quantum tunneling. *Compare* Ex. 1024 ¶ 150, *with* Ex. 1035, 3273 (noting the strong influence of tunnel barrier height on  $\Delta R/R$ ) *and* Ex. 1024 ¶¶ 45–49. Accordingly, I find persuasive Dr. Bokor’s testimony that one of ordinary skill in the art would have been motivated to lower the barrier height to facilitate tunneling of parallel electrons (i.e., to lower the  $R_p$ ) to increase TMR. Ex. 1024 ¶ 152.

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<sup>18</sup> Wang et al., *70% TMR at Room Temperature for SDT Sandwich Junctions With CoFeB as Free and Reference Layers*, 40 IEEE Trans. Magn. 2269–71 (2004).

<sup>19</sup> Kim et al., *MRAM Technology for High Density Memory Application*, 2 J. Semicond. Tech. Sci. 185–96 (2002).

In addition, as I discuss below, Bowen and Soukup each teach that for a MgO layer that there is an inverse relationship between oxygen vacancy defects and barrier height. *See infra* Section I.C.2. In particular, an increase in oxygen vacancy defects lowers the MgO layer's barrier height. *Id.*

Accordingly, at this stage, I agree with Petitioner and find that one of ordinary skill in the art would have been motivated to adjust oxygen vacancy defects in the MgO layer to improve TMR by lowering the barrier height. Pet. 39–40; Ex. 1024 ¶¶ 154, 156.

I find unavailing Patent Owner's argument that "nothing supports Petitioner's assertion that [one of ordinary skill in the art] would have expected that lowering Bowen's barrier height would have increased the TMR." Prelim. Resp. 21. This argument subsumes two separate arguments: that Petitioner does not show that (i) lowering barrier height lowers  $R_p$ , and (ii) lowering  $R_p$  increases TMR. *See id.* at 19–29.

First, for the reasons above, I disagree at this stage with Patent Owner that Petitioner does not show that lowering barrier height lowers  $R_p$ . *See* Ex. 1024 ¶¶ 45–49, 150; Ex. 1035, 3273.

Second, I find unavailing Patent Owner's arguments that Petitioner fails to show that lowering  $R_p$  increases TMR because Petitioner does not show 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  $R_p$ ." Prelim. Resp. 22–29. Rather, Dr. Bokor testifies that "lowering the resistance (barrier height) for parallel spin electrons compared to antiparallel improved TMRs." Ex. 1024 ¶ 150 (citing Ex. 1035, 3273). I find that this testimony reflects that  $R_p$  is lowered disproportionately, or otherwise the TMR would not have

“improved.” *Id.* Moreover, at this stage, I find this testimony is sufficiently supported. *See* Ex. 1035, 3273 (noting the strong influence of tunnel barrier height on  $\Delta R/R$ ). I also note that the TMR equation comprises only two variables (i.e.,  $R_p$  and  $R_{ap}$ ) and that the art teaches a desire to increase TMR, as I discuss above. Thus, in my view, one of ordinary skill in the art would have found it obvious to lower  $R_p$  disproportionately to  $R_{ap}$  to increase TMR. Moreover, Patent Owner chooses values for  $R_p$  and  $R_{ap}$  to support attorney argument without any evidence that such values are possible. Prelim. Resp. 23. Thus, these arguments have little probative value. *See In re Geisler*, 116 F.3d 1465, 1471 (Fed. Cir. 1997) (explaining that attorney arguments that are unsupported by factual evidence are entitled to little probative value).

In addition, I find inapposite Patent Owner’s argument that “[b]arrier height is not the same thing as parallel resistance  $R_p$  as Petitioner itself acknowledges.” Prelim. Resp. 20 n.8 (citing Pet. 38). Rather, as Petitioner argues and Dr. Bokor testifies, lowering barrier height lowers  $R_p$ —not that they are the same. *See* Ex. 1024 ¶¶ 150–152.

Lastly, I find unavailing Patent Owner’s argument that Petitioner improperly incorporates by reference from Dr. Bokor’s declaration. *See* Prelim. Resp. 26–27. 37 C.F.R. § 42.6(a)(3) states that “[a]rguments must not be incorporated by reference from one document into another document.” Rather, Petitioner makes arguments and cites to portions of Dr. Bokor’s declaration, which is evidence—not argument. *Guardant Health, Inc. v. Vidal*, No. 2021-1104, 2023 WL 3262962, at \*5 n.4 (Fed. Cir. May 5, 2023) (“The Director argues Guardant improperly incorporated arguments from Dr. Quackenbush’s declaration in violation of 37 C.F.R.

§ 42.6(a)(3),” but “[t]his argument is inapt because Guardant’s response brief maps claim 1’s elements . . . by relying on the evidence and expert declaration, not by incorporating legal arguments.”). I view Petitioner’s citations to Dr. Bokor’s declaration here as providing the detailed explanations required of an expert to support their opinions, rather than attempting to make additional legal arguments.

In sum, at this stage, I find that Petitioner shows that one of ordinary skill in the art would have been motivated to combine Bowen and Soukup in the manner Petitioner does.

### *C. Challenged Claim 1*

#### *1. Undisputed Limitations*

There is no dispute that Petitioner shows that Bowen teaches all but one of the limitations of claim 1. For example, there is no dispute that Bowen teaches a MTJ with ferromagnetic material layers having the claimed body centered cubic structure on each side of a tunnel barrier layer. Pet. 30–34. Nor is it disputed that Bowen teaches that the “tunnel barrier layer is formed by a single-crystalline  $\text{MgO}_x$  (001) ( $0 < x < 1$ ) . . . in which (001) crystal plane is preferentially oriented.” *Id.* at 34–36. In other words, there is no dispute that Bowen teaches that its MgO tunnel barrier layer has oxygen vacancy defects.<sup>20</sup>

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<sup>20</sup> This inequality denotes that oxygen vacancy defects exist such that the ideal stoichiometry of 1:1 for the magnesium and oxygen is not met. *See* Ex. 1024 ¶¶ 74–75, 140; *see also id.* ¶ 139 (“ $\text{MgO}_x$ , non-stoichiometric MgO, and oxygen vacancy defects in an MgO layer are interchangeable terminology and all refer to the same phenomenon: missing oxygen atoms in the MgO crystal.”) (citations omitted); Pet. 15–16.

The last limitation of claim 1 is “wherein a tunnel barrier height between a bottom of a conduction band of said tunnel barrier layer and a Fermi energy of at least one of said first and second ferromagnetic layers is a discontinuous value in a range of 0.2 to 0.5 eV.” Ex. 1001, 9:38–42. Petitioner argues that “[t]he claim language ‘a tunnel barrier height between a bottom of a conduction band of said tunnel barrier layer and a Fermi energy of at least one of said first and second ferromagnetic layers is a discontinuous value’ merely recites the definition of a ‘tunnel barrier height’ in an MTJ.” Pet. 37 (citing Ex. 1001, 2:59–63, 3:38–42; Ex. 1024 ¶¶ 48, 144–146). Patent Owner does not dispute this argument.

*2. Range of 0.2 to 0.5 eV*

The parties dispute whether the combination of Bowen and Soukup teaches having a tunnel barrier height “in a range of 0.2 to 0.5 eV” for Bowen’s MgO barrier layer. Pet. 37–40; Prelim. Resp. 44–61.

There are two distinct teachings in each of Bowen and Soukup that Petitioner cites for MgO layers: (i) specific barrier heights and (ii) that there is an inverse relationship between oxygen vacancy defects and barrier height. Pet. 37–40.

In particular, Petitioner argues that Bowen teaches a barrier height of 0.9 eV, and Soukup teaches a barrier height of 0.33 eV. Pet. 37 (citing Ex. 1026, 1656; Ex. 1028, Abstract, 3231–32, Fig. 5, Table I; Ex. 1024 ¶ 148).

In addition, Petitioner makes the following arguments:

Soukup taught that oxygen vacancy defects had an impact on the barrier height for MgO. EX1024 ¶149. Soukup suggested a “higher barrier?[] present for the devices fabricated with more oxygen present during MgO deposition, which could mean more stoichiometric oxide films” (i.e., fewer oxygen vacancy defects).

EX1028 at 3232; EX1024 ¶149. In other words, Soukup suggested a higher level of oxygen vacancy defects lowered the barrier height. *See id.* One of skill reading Soukup would understand there was a relationship between oxygen vacancy defects and barrier height. EX1024 ¶149.

*Id.* at 37–38. In other words, Petitioner argues that Soukup teaches an inverse relationship between MgO’s oxygen vacancy defects and barrier height. *Id.*

Petitioner then argues that one of ordinary skill in the art would have applied Soukup’s teachings, including Soukup’s 0.33 eV barrier height, to Bowen to achieve a barrier height within the claimed range. Pet. 38–39. It is this set of arguments that is the majority’s focus. Maj. 16–20. I agree with the majority that Soukup’s teaching of a 0.33 eV barrier height is suspect. For example, Soukup’s Table I seems to teach inconsistent results, as the majority addresses. *Id.* at 16–18. I note, however, that Table I is not two-dimensional (i.e., only reflecting barrier height and oxygen vacancy defects (via oxygen pressure)). Ex. 1028, 3233. Rather, Table I shows that the oxide thickness and overlayer thickness are also varied for the tested devices. *Id.* In my view, whether these variances explain the apparent inconsistent results is best left for trial, rather than deciding now without the benefit of a full record. *See Trivascular, Inc., v. Samuels*, 812 F.3d 1056, 1068 (Fed. Cir. 2016) (“[T]here is a significant difference between a petitioner’s burden to establish a ‘reasonable likelihood of success’ at institution, and actually proving [unpatentability] by a preponderance of the evidence at trial.”).

Regardless, Petitioner also sets forth alternative arguments (i.e., “also would have been obvious”) which rely on Bowen and Soukup’s teaching of

the inverse relationship between oxygen vacancy defects and barrier height, and not Soukup's 0.33 eV barrier height. Pet. 37–39. The majority overlooks these alternative arguments, despite listing them as being made. Maj. 14–15, 22 n.14. These arguments are as follows:

The claimed tunnel barrier height range of 0.2 to 0.5 eV *also would have been obvious*. EX1024 ¶154. One of skill was aware that oxygen vacancy defects impacted the barrier height. Bowen itself hypothesized that the low barrier height they 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.” EX1026 at 1656; EX1024 ¶154. Soukup observed a relationship between barrier height and MgO stoichiometry (oxygen vacancy defects). EX1028 at 3232, 3236 (“[B]arrier height was a function of the amount of oxygen present . . . with a higher barrier for larger amounts of oxygen present” and “more stoichiometric” MgO film.). Thus, one of skill would have been motivated to adjust oxygen vacancy defects to improve TMR by lowering the barrier height as taught by Soukup.

Pet. 39–40 (*italics emphasis added*) (remaining alterations in original).

In my view, Petitioner shows that the combination of Bowen and Soukup teaches an inverse relationship between oxygen vacancy defects and barrier height for an MgO layer. Such a relationship would provide a result-effective variable.<sup>21</sup> *In re Applied Materials, Inc.*, 692 F.3d 1289, 1297 (Fed. Cir. 2012) (“[T]he prior art need not provide the exact method of optimization for the variable to be result-effective. A recognition in the prior art that a property is affected by the variable is sufficient to find the variable result-effective.”). And thus, I find that knowing this

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<sup>21</sup> I agree with the majority that inherency is not a relevant legal doctrine here. Maj. 20–22.

result-effective variable relationship, coupled with the motivation to lower the barrier height (which I find above), one of ordinary skill in the art would have found it obvious to adjust the MgO's oxygen vacancy defects to achieve a barrier height within the claimed range. See *Pfizer Inc. v. Sanofi Pasteur Inc.*, 94 F.4th 1341, 1347 (Fed. Cir. 2024) (“[W]here the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation.”).

Notably, the prior art does not need to teach a range that overlaps the claimed range. *Id.* at 1347–48. In other words, Bowen and Soukup do not need to disclose a barrier height which is within the 0.2 to 0.5 eV range to render this limitation obvious. *Id.* Rather, the *Pfizer* court explains the following:

A routine optimization analysis generally requires consideration whether a person of ordinary skill in the art would have been motivated, with a reasonable expectation of success, to bridge any gaps in the prior art to arrive at a claimed invention. Where that gap includes a parameter not necessarily disclosed in the prior art, it is not improper to consider whether or not it would have been recognized as result-effective. If so, then the optimization of that parameter is “normally obvious.”

*Id.* at 1348 (citing *In re Antonie*, 559 F.2d 618, 620 (CCPA 1977)).

Accordingly, I find the claimed range obvious over Bowen and Soukup's teachings.

Moreover, there is no record evidence “that the variables interact[] in an unpredictable or unexpected way [which] could render the combination nonobvious.” *In re Applied Materials*, 692 F.3d at 1297–98 (citing *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 421 (2007)). To the contrary, the '403 patent's Specification simply discloses 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).” Ex. 1001, 6:52–55; Pet. 40. Similarly, Patent Owner asserted in related district court litigation that accused products met a “wherein said magnesium oxide has a tunnel barrier height in a range of 0.2 to 0.5 eV” limitation because “the presence of oxygen vacancy defects indicates a tunnel barrier height as claimed,” and “[a] tunnel barrier height as claimed is the result of oxygen vacancy defects, as explained in the ’403 [p]atent.” Ex. 1064,<sup>22</sup> 19; Pet. 40. This too does not evidence an unpredictable or unexpected interaction.

In addition, I note that Petitioner clearly lays out its obviousness theory based on the known inverse relationship between oxygen vacancy defects and barrier height for an MgO layer, although Petitioner does not refer to the relationship as a “result-effective variable.” There is nothing talismanic about this phrase, however. Rather, I follow Federal Circuit precedent for this obviousness theory based on the arguments as laid out by Petitioner. *See* Consolidated Trial Practice Guide November 2019,<sup>23</sup> 39 (“Another factor to keep in mind is that judges of the Board are familiar with the general legal principles involved in issues which come before the Board. Accordingly, unless there is a dispute over the applicable law, extended discussions of general patent law principles may not be necessary.”).

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<sup>22</sup> Claim Chart, Ex. D to Complaint, *Godo Kaisha IP Bridge I v. Western Digital Corporation*, Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024).

<sup>23</sup> Available at <https://www.uspto.gov/TrialPracticeGuideConsolidated>.

In addition, I disagree with the majority that we can disregard Soukup's teaching that having a higher level of oxygen vacancy defects lowers the MgO's barrier height. Maj. 23–24 & n.15. I recognize that Soukup acknowledges that the zero-field intercept plot and the Arrhenius plot showed contradictory results as to this relationship, depending on which plot was examined. Ex. 1028, 3229 (“The 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.”). But measurement techniques cannot alter the actual chemistry of the MgO layer, or its physics.

Tellingly, despite the differing zero-field intercept plot and the Arrhenius plot results, Soukup still teaches that other “results are consistent with the hypothesis that admitting oxygen gas during deposition of the MgO film increases the stoichiometry of the film as seen by an increased barrier height.” *Id.* at 3232. In other words, Soukup still teaches the inverse relationship. And notably, Soukup's dissertation maintains this teaching that having a higher level of oxygen vacancy defects lowers the barrier height, despite correcting a barrier height measurement for the Arrhenius plot technique. *See* Ex. 2007,<sup>24</sup> 61. Moreover, Bowen also teaches for a MgO layer that having a higher level of oxygen vacancy defects lowers the barrier height. Ex. 1026, 1656.

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<sup>24</sup> Soukup, R., *Hot Electron Transport in Vacuum Deposited Thin Film Emission Diodes*, Univ. of Minn. Ph.D. dissertation (1969) (Ex. 2007).

Thus, taken as a whole, I do not find it reasonable to disregard Soukup's teaching that having a higher level of oxygen vacancy defects lowers the MgO's barrier height.

I also disagree with the majority's justification for not addressing Petitioner's alternative arguments based on Bowen and Soukup. Maj. 22 n.14. In my view, the majority incorrectly narrows the arguments made in the Petition. *See Netflix, Inc. v. DivX, LLC*, 84 F.4th 1371, 1377 (Fed. Cir. 2023) (“[T]he Board should not take an overly mechanistic view of a petition and decline to address an argument because the petitioner did not present it with ideal vigor and clarity.”).

In addition, I find Patent Owner's arguments that Soukup is directed to (i) emission diodes and not magnetoresistive devices, (ii) gold electrode emissions without magnetization mechanisms, and (iii) Schottky emissions (Prelim. Resp. 31–37), are inapposite to Soukup's teaching that having a higher level of oxygen vacancy defects in a MgO layer lowers its barrier height. And again, it is Bowen that teaches the claimed MTJ structure. *See supra* Section I.C.1.

In sum, I find that Petitioner shows that the claimed range would have been obvious over Bowen and Soukup's teachings.

## II. CONCLUSION

For the reasons discussed above, it is my view that Petitioner shows a reasonable likelihood of prevailing on its challenge to independent claim 1 based on Bowen and Soukup, and I respectfully dissent from the denial of institution.

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