

Filed on behalf of Western Digital Technologies, Inc.

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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.

Case No. IPR2025-00701
U.S. Patent No. 10,367,138

**PETITION FOR *INTER PARTES* REVIEW OF
U.S. PATENT NO. 10,367,138**

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Exhibit No.	Description
1001	U.S. Patent No. 7,884,403 (“403 Patent”)
1002	File History for U.S. Patent No. 7,884,403
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1004	File History for U.S. Patent No. 8,319,263
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1017	U.S. Patent No. 11,968,909 (“909 Patent”)
1018	File History for U.S. Patent No. 11,968,909
1019	Patent Family Tree
1020	Japanese Patent No. JP2004071186
1021	English Translation of Japanese Patent No. JP2004071186, from ‘372 Patent File History (EX1016)
1022	Japanese Patent Application No. JP2004313350
1023	Certified English Translation (with Translator Declaration) of Japanese Patent Application No. JP2004313350
1024	Declaration of Jeffrey Bokor, Ph.D.

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1063	Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024) (without exhibits)
1064	Claim Chart for ’403 Patent, Exhibit D to Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024)

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1065	Claim Chart for '263 Patent, Exhibit E to Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024)
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1075	Claim Chart for '167 Patent, Exhibit HH to First Amended Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024)

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1076	Claim Chart for '134 Patent, Exhibit II to First Amended Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024)
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1086	File History for U.S. Patent Application No. 18/232,576
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1090	U.S. Patent No. 7,252,852 to Parkin (“Parkin-852”)
1091	U.S. Patent No. 7,598,555 to Parkin (“Parkin-555”)

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1092	File History for U.S. Patent Application No. 10/824,835 to Parkin (“Parkin-835”)
1093	Declaration of Dr. Sylvia Hall-Ellis (“Hall-Ellis Decl.”)
1094	Curriculum Vitae of Dr. Sylvia Hall-Ellis
1095	Copy of Wang (EX1055) from Linda Hall Library of Science, Engineering & Technology (Kansas City, Missouri)

LIST OF CHALLENGED CLAIMS

1[pre] A magnetic tunnel junction (MTJ) device, comprising:

1[a] a first electrode comprising a first ferromagnetic material layer that includes Co, Fe, and B;

1[b] a barrier layer disposed over the first electrode, the barrier layer comprising a magnesium oxide (MgO) layer that is formed of a polycrystalline MgO in which a (001) crystal plane is preferentially oriented; and

1[c] a second electrode disposed over the barrier layer and comprising a second ferromagnetic material layer that includes Co, Fe, and B, and

1[d] wherein each of the first and second ferromagnetic material layers is entirely crystallized,[] and

1[e] wherein a value of x in MgO_x for the MgO layer is greater than 0 and less than 1.

2. The MTJ device of claim 1, wherein the first ferromagnetic material layer is in direct contact with the barrier layer, and wherein the second ferromagnetic material layer is in direct contact with the barrier layer.

3. The MTJ device of claim 1, wherein the first ferromagnetic material layer is in direct contact with the MgO layer, and wherein the second ferromagnetic material layer is in direct contact with the MgO layer.

4. The MTJ device of claim 1, wherein a barrier height ϕ of the barrier layer is in a range of 0.2 to 0.5 eV.

5[pre] The MTJ device of claim 4,

5[a] wherein the barrier height ϕ of the barrier layer is obtained by fitting J-V characteristics of the MTJ device to an equation (1):

$$J = [(2m\phi)^{1/2} / \Delta s] (e/h)^2 \times \exp[-(4\pi\Delta s/h) \times (2m\phi)^{1/2}] \times V \quad (1)$$

5[b] where J is a tunnel current density flowing through the barrier layer, V is an applied bias voltage that is 100 mV or smaller, m is the free electron mass, e is the elementary electric charge, h is Planck's constant, Δs is an effective

thickness of the barrier layer that is equivalent to ($t_{\text{MgO}} - 0.5 \text{ nm}$), and t_{MgO} is an actual thickness of the barrier layer.

6. The MTJ device of claim 1, wherein a value of x in MgO_x for the MgO layer is greater than 0.9 and less than 1.

7[pre] A magnetic tunnel junction (MTJ) device, comprising:

7[a] a first electrode made of a first CoFeB layer;

7[b] a barrier layer made of a magnesium oxide (MgO) layer that is a polycrystalline layer in which a (001) crystal plane is preferentially oriented; and

7[c] a second electrode made of a second CoFeB layer, and

7[d] wherein the barrier layer is located between the first electrode and the second electrode, and

7[e] wherein both the first and second CoFeB layers are entirely crystallized, and

7[f] wherein a value of x in MgO_x for the MgO layer is greater than 0 and less than 1.

8. The MTJ device of claim 7, wherein the first CoFeB layer is in direct contact with the MgO layer, and wherein the second CoFeB layer is in direct contact with the MgO layer.

9. The MTJ device of claim 7, wherein the MgO layer and the first CoFeB layer form a first interface of the MTJ, and wherein the MgO layer and the second CoFeB layer form a second interface of the MTJ.

10. The MTJ device of claim 7, wherein a barrier height ϕ of the MgO layer is in a range of 0.2 to 0.5 eV.

11[pre] The MTJ device of claim 10,

11[a] wherein the barrier height ϕ of the MgO layer is obtained by fitting J-V characteristics of the MTJ device to an equation (1):

$$J = [(2m\phi)^{1/2} / \Delta s] (e/h)^2 \times \exp[-(4\pi\Delta s/h) \times (2m\phi)^{1/2}] \times V \quad (1)$$

11[b] where J is a tunnel current density flowing through the MgO layer, V is an applied bias voltage that is 100 mV or smaller, m is the free electron mass, e is the elementary electric charge, h is Planck's constant, Δs is an effective thickness of the MgO layer that is equivalent to $(t_{\text{MgO}} - 0.5 \text{ nm})$, and t_{MgO} is an actual thickness of the MgO layer.

12[pre] A magnetic tunnel junction (MTJ) device, comprising:

12[a] a first ferromagnetic material layer that includes Co, Fe, and B;

12[b] a barrier layer disposed on the first ferromagnetic material layer, the barrier layer comprising a magnesium oxide (MgO) layer that is a polycrystalline MgO in which (001) crystal plane is preferentially oriented; and

12[c] a second ferromagnetic material layer that is disposed on the barrier layer and includes Co, Fe, and B, and

12[d] wherein each of the first and second ferromagnetic material layers is entirely crystallized, and wherein a value of x in MgO_x for the MgO layer is greater than 0 and less than 1.

13. The MTJ device of claim 12, wherein a barrier height ϕ of the barrier layer is in a range of 0.2 to 0.5 eV.

14[pre] The MTJ device of claim 13,

14[a] wherein the barrier height ϕ of the barrier layer is obtained by fitting J-V characteristics of the MTJ device to an equation (1):

$$J = [(2m\phi)^{1/2} / \Delta s] (e/h)^2 \times \exp[-(4\pi\Delta s/h) \times (2m\phi)^{1/2}] \times V \quad (1)$$

14[b] where J is a tunnel current density flowing through the barrier layer, V is an applied bias voltage that is 100 mV or smaller, m is the free electron mass, e is the elementary electric charge, h is Planck's constant, Δs is an effective thickness of the barrier layer that is equivalent to $(t_{\text{MgO}} - 0.5 \text{ nm})$, and two [sic] is an actual thickness of the barrier layer.

I. INTRODUCTION

All claims of the '138 Patent challenged here purport to claim an MTJ with crystallized CoFeB electrodes and a polycrystalline MgO barrier layer, among other features. EX1011 at Claims 1, 7, 12. The Examiner allowed the '138 claims in 2019. But when examining IP Bridge's latest claim iteration in January 2025, the same Examiner recognized that prior art to Parkin and others taught a "polycrystalline" barrier layer "made of MgO" and "partially or entirely crystallized" electrodes. EX1086 at 258-59. He then rejected claims in IP Bridge's last two applications, and IP Bridge's only response was to abandon them. *Infra* §II.D.

IP Bridge is also in retreat at the PTAB. Facing IPRs, IP Bridge disclaimed the result-effective claims to oxygen vacancy defects (including MgO_x where $0.9 < x < 1$) in the '372 and '909 Patents in January and February 2025. IPR2024-01448, EX2017; IPR2024-01494, EX2018. Yet it has not disclaimed the equivalent Claim 6 in the '138 Patent challenged here.

This Petition follows. It presents three grounds based on Parkin, Bowen, Wang, and Soukup, demonstrating all claims of the '138 Patent should be found obvious and cancelled.

II. BACKGROUND

A. The District Court Litigation

A few years ago, Patent Owner IP Bridge bought a family of patents on MgO-based MTJs, including the '138 Patent challenged here. EX1067 ¶¶3, 10. In March 2024, IP Bridge filed suit against Western Digital, asserting that essentially its entire hard drive product line infringed three patents. *Id.* ¶¶28-30, 33-35. Then it added six more patents to the case. EX1067. The case was transferred to the Northern District of California, and IP Bridge stipulated to a stay due to the eight pending IPRs. EX1080; EX1085.

B. Technical Background

This Petition is supported by the declaration of U.C. Berkeley Professor Bokor (EX1024) explaining the development and operation of MRAM (¶¶30-35); efforts to increase TMR (¶¶36-44); quantum tunneling (¶¶45-49); research into barrier layers and ferromagnetic materials, including CoFeB, to increase MRAM TMR (¶¶50-72); and oxygen vacancy defects in MgO thin films (¶¶73-82).

C. The '138 Patent And Its Prosecution

The '138 Patent is one of ten issued patents in the same family, nine of which IP Bridge has asserted against Western Digital. EX1019; EX1067. All nine patents are now challenged in IPR.

The '138 independent claims purport to cover, *inter alia*, an “MTJ[] device” with a “poly-crystalline” MgO barrier layer with oxygen vacancy defects (“MgO_x” where x is “greater than 0 and less than 1”) placed between two CoFeB electrodes. EX1011 at Claims 1, 7, 12; EX1024 ¶¶83-86. Other claims specify a barrier height “in a range of 0.2 to 0.5 eV.” EX1011 at Claims 4, 10, 13.

All patents in this family were examined by the same Examiner. *E.g.*, EX1011 at 1 (Primary Examiner—Alonzo Chambliss); EX1001 at 1 (same). The Examiner initially rejected the claims for double patenting over U.S. Patent No 8,405,134 challenged in IPR2024-001447. EX1012 at 116-19. After an interview and a terminal disclaimer, he allowed the claims. *Id.* at 125-29, 150.

Applicant then filed an RCE, amended the claims again, and submitted an extensive IDS with almost 200 references. EX1012 at 167-90. The Examiner rejected claims based on a different Parkin reference (U.S. Patent 7,252,852, EX1090) (“Parkin-852”) and Ohba. EX1012 at 197-203. Applicant again amended, arguing for allowance because Parkin-852 only taught “CoFe or CoFe/Fe” electrodes, not the “crystallized” CoFeB electrodes it claimed. *Id.* at 293-94. Parkin-852 does not include the Figure 3A embodiment with crystallized CoFeB electrodes from Parkin (EX1062) submitted here. *Compare* EX1090, Figs. 2, 11, 15-16, *with* EX1062, Fig. 3A.

In another rejection, the Examiner rejected claims based on patents to Sony, Nashimoto, and Parkin. EX1012 at 306-13. The Examiner invoked Parkin only for teaching ferromagnetic layers with a BCC structure. *Id.* at 309. Applicant did not point out Parkin's disclosure of crystallized CoFeB electrodes and instead amended its claims to include the oxygen vacancy defect limitations (e.g., "MgO_x" where x "is greater than 0 and less than 1") that the Examiner had initially said were not taught in the prior art. *Id.* at 329-36.

The Examiner explained his belief that the '138 claims were allowable because "the prior art of record does not teach or suggest" a "barrier layer" with a barrier height "in a range of 0.2 to 0.5 eV" or oxygen vacancy defects ("value of x in MgO_x" that "is greater than 0 and less than 1"). EX1012 at 312. Applicant never corrected him.

He then allowed the '138 claims challenged here. *Id.* at 338.

D. IP Bridge Abandons All Of Its Pending Applications

After Western Digital filed the prior IPR petitions, IP Bridge abandoned its final two pending continuations in the '138 Patent's family: U.S. Applications 18/232,576 ("576-App.") and 18/642,280 ("280-App."). EX1086; EX1087.

Both applications were also assigned to the same Examiner that handled the rest of the patent family. EX1086 at 182 (Examiner: Chambliss, Alonzo); EX1087 at 197 (same).

After IP Bridge received expedited Track I examination and submitted a terminal disclaimer to overcome a double-patenting rejection, the Examiner allowed the claims of the 576-App. EX1086 at 147, 189-92, 214. He determined that the “prior art of record does not teach or suggest” claim limitations a tunnel barrier of “MgOx(001) with oxygen vacancy defects and ($0 < x < 1$)” or “a barrier height in a range of 0.2 eV to 0.5 eV.” *Id.* at 219. IP Bridge paid the issue fee. *Id.* at 222.

But then the Office withdrew the 576-App. “from issue due to unpatentability,” and rejected most of the claims. EX1086 at 228, 254-61. The Examiner found that “Kishi [EX1088/EX1089] teaches a barrier height of (0.1 eV to 0.85 eV) and (.2eV to .5eV).” *Id.* at 257. He further found that U.S. Patent 7,598,555 (EX1091) to “Parkin discloses a tunnel barrier layer (i.e. made of MgO) comprises a polycrystalline magnesium oxide” and ferromagnetic material layers that are “partially or entirely crystallized.” *Id.* at 258-59. In January 2025, the Examiner issued a Notice of Abandonment after IP Bridge reported that “the case has gone abandon[ed].” *Id.* at 262-63.

IP Bridge also received Track I consideration for the 280-Appl. EX1087 at 152-53. The examiner rejected all pending claims for similar reasons, *id.* at 197-205, and IP Bridge’s attorney abandoned that application during the same “conversation on 1/3/2025,” *id.* at 207-08.

III. CLAIM CONSTRUCTION

Petitioner submits the claim terms should be given their plain and ordinary meaning and no claim construction is necessary to find the claims unpatentable, *see Vivid Techs. v. Am. Sci. & Eng'g*, 200 F.3d 795, 803 (Fed. Cir. 1999), and reserves the right to propose constructions in response to Patent Owner's arguments. EX1024 ¶¶87-88.

IV. STATEMENT OF PRECISE RELIEF REQUESTED FOR EACH CHALLENGED CLAIM (37 C.F.R. § 42.104(b)(1)-(2))

A. Grounds Presented

Petitioner requests cancellation of Claims 1-14 on the following grounds.

Ground 1: Claims 1-4, 7-10, and 12-13 are obvious over Parkin in view of Wang and Soukup. Soukup is optional in the combinations for Claims 1-3, 7-9, and 12.

Ground 2: Claim 5-6, 11, and 14 are obvious over Parkin in view of Wang, Soukup, and Bowen.

Ground 3: Claims 1-14 are obvious over Bowen in view of Wang and Soukup. Soukup is optional in the combinations for Claims 1-3, 7-9, and 12.

B. The Prior Art

1. Bowen and Soukup

The '138 Patent is a pre-AIA patent. Under §102(b), the effective filing date is the international filing date, not the filing date of any foreign priority documents.

See, e.g., 35 U.S.C. §102(b) (pre-AIA); MPEP §2139.01. Thus, “the one-year [bar] is measured from the filing date of the earliest application filed in the United States (directly or through the PCT) and not from the dates of earlier filed foreign patent applications.” MPEP §2151. The ’138 Patent claims priority to the ’403 Patent PCT application, PCT/JP2005/04720, EX1011 at 2, [63], 1:6-27, with an international filing date of March 10, 2005, EX1001 at [22]. Accordingly, the critical date for the ’138 Patent is March 10, 2004, *Group One v. Hallmark Cards*, 254 F.3d 1041, 1044-45 (Fed. Cir. 2001).

Bowen and Soukup are each prior art under at least pre-AIA 35 U.S.C. §102(a) and (b) because they were published before the critical date:

- Bowen was published on September 10, 2001. EX1026 at 1655; EX1024 ¶¶90-91.
- Soukup was published on July 1, 1970. EX1028 at cover, 3229; EX1024 ¶¶92-94.

2. Parkin and Wang

Parkin is prior art under pre-AIA 35 U.S.C. §102(a) and (e), and Wang is prior art under §102(a), because they were filed before the earliest possible filing date and before the purported invention of the subject matter of the ’138 Patent. All ’138 Patent claims require ferromagnetic material layers with “CoFeB” or “that include[] Co, Fe, and B.” EX1011 at Claims 1, 7, 12. There is no disclosure of a CoFeB layer

in the March 12, 2004 Japanese priority application (JP 2004-071186) for the '138 Patent. EX1011 at [30]. The earliest disclosure of CoFeB is the October 28, 2004 Japanese priority application (JP 2004-313350), rendering Parkin and Wang prior art under §102(a) and (e).

- Parkin (U.S. Patent No. 7,270,896) was filed on July 2, 2004. EX1062 at [22]; EX1024 ¶¶97-98.
- Wang was received on October 9, 2003, presented at the IEEE Joint Magnetism and Magnetic Materials Conference on January 5-9, 2004, published in July 2004, and publicly accessible by August 2004. EX1055 at 2269; EX1095; EX1024 ¶¶95-96; EX1093 ¶¶58, 65.

V. LEVEL OF ORDINARY SKILL IN THE ART

One of ordinary skill in the art as of 2004 would have had

- a Ph.D. or master's degree in electrical engineering, physics, materials science, or a related field, and at least one year or four years, respectively, of experience in the research, design, and/or development of magnetic/spintronic devices, or the equivalent.

EX1024 ¶¶25-29. Less work experience may be compensated by a higher level of relevant education and vice versa. EX1024 ¶25. This level of ordinary skill would be the same if the relevant time period were around the March 12, 2004 or October

28, 2004 Japanese priority applications, or the March 10, 2005 PCT filing date. *Id.* ¶¶24-25.

VI. GROUND 1: CLAIMS 1-4, 7-10, 12-13 ARE OBVIOUS OVER PARKIN IN VIEW OF WANG AND SOUKUP

A. Claim 1

Claim 1 would have been obvious over Parkin in view of Wang and optionally Soukup. EX1024 ¶¶100-86.

1. Claim 1[preamble]: “A magnetic tunnel junction (MTJ) device, comprising:”

To the extent limiting, Parkin disclosed or suggested an “*MTJ device*.” *E.g.*, EX1062 at 16:47-53, Fig. 3A, 16:47-17:59 (describing Figure 3A); EX1024 ¶¶101-04; *see infra* Claims 1[a]-[e], §§VI.A.2-VI.A.6.

The '138 Patent acknowledges MTJs were known. EX1011 at Figs. 8(A)-8(B), 1:44-2:2; EX1024 ¶¶31-35, 104.

2. Claim 1[a]: “a first electrode comprising a first ferromagnetic material layer that includes Co, Fe, and B;”

This limitation was taught or suggested by Parkin in view of Wang. EX1024 ¶¶105-16.

As specified in Claim 1[b], “first” refers to the lower electrode positioned below the tunnel barrier layer. EX1011 at 9:59-62; EX1024 ¶106. MTJs with ferromagnetic material layers were conventional. EX1011 at 1:46-51, Figs. 8(A)-8(B); EX1045 at 1; EX1024 ¶¶54-62, 107.

Claim 1[a] does not specify any molecular composition or stoichiometry of the claimed ferromagnetic material layer including Co, Fe, and B, and thus, any alloy including Co, Fe, and B satisfies it. EX1011 at 9:57-58; EX1024 ¶108. One of skill would have understood that ferromagnetic electrodes including Co, Fe, and B referred to CoFeB, and that CoFeB and FeCoB refer to the same alloy. EX1024 ¶108.

Parkin disclosed that a **lower ferromagnetic layer** “115 of 35 Å $\text{Co}_{70}\text{Fe}_{30}$ is deposited” on top of an antiferromagnetic layer 116 as shown in Figure 3A below. EX1062 at 17:14-19; EX1024 ¶109.

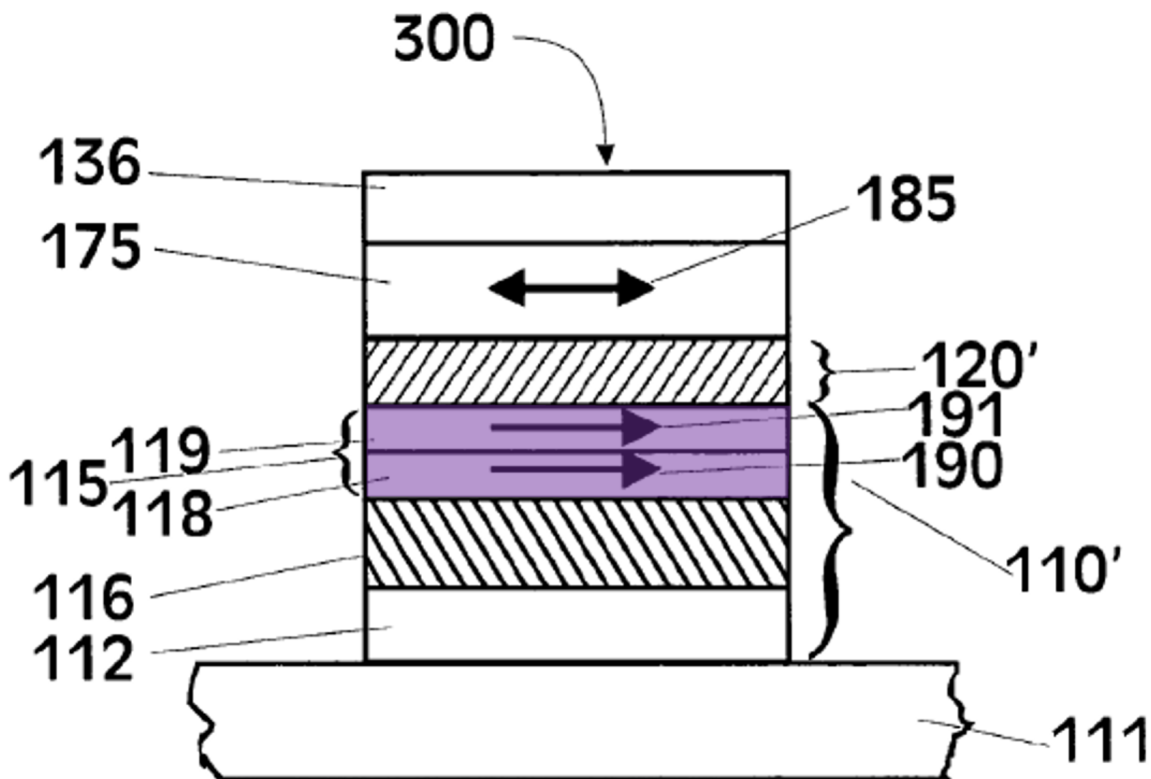


FIG. 3A

EX1062 at Fig. 3A (annotated).

It would have been obvious to substitute CoFeB for Parkin's lower CoFe reference electrode as described in Wang. EX1024 ¶110. One of skill would have looked to Wang's teachings to improve Parkin's MTJ because both Parkin and Wang focused on improving the TMR of magnetoresistive devices, a problem to which the '138 Patent was directed. EX1062 at 1:18-21 (“[T]his invention relates to an improved MTJ exhibiting high tunneling magnetoresistance...”); EX1055 at 2269-70 (describing “a higher TMR value” as a “benefit of using CoFeB” and that “A high TMR value is desirable because it leads to greater signal level, lower power consumption, higher speed, and larger design margin for devices such as MRAM, read heads, and a variety of magnetic field sensors.”); EX1011 at Abstract, 1:32-2:29; EX1024 ¶111. Both Parkin and Wang were directed to improving MRAM memory performance, as was the '138 Patent. EX1062 at 2:65-3:1 (“[F]or non-volatile magnetic memory storage cells, high TMR values are needed for improving the performance of these devices.”); EX1055 at 2269 (desirability of a “high TMR value” for MRAM); EX1011 at 2:57-60; EX1024 ¶112. Both also used ferromagnetic electrodes. EX1062 at 1:18-21; EX1055 at 2270-71; EX1024 ¶112.

Because it was known that CoFeB had been successfully used as electrodes for MTJs, one of skill would have found it to be a straightforward, predictable, and

desirable improvement to the TMR of Parkin's MTJ. EX1024 ¶113; EX1030 ¶¶24-29; EX1055 at 2269-71; EX1056 ¶¶39, 78.

Wang compared an MTJ device using a CoFeB free electrode and a CoFe reference electrode, like Parkin's, to an MTJ device using CoFeB free and reference electrodes and concluded that "[t]he TMR value is indeed improved to be 65.4%, comparing to 60.8% with CoFeB on only one side of the tunnel barrier." EX1055 at 2270. Wang advised: "With such a large increase of TMR value by changing the free layer from NiFeCo to CoFeB, it is natural to replace both the free and pinned layers to CoFeB to further increase the TMR value." *Id.* Other researchers had also observed higher TMRs with CoFeB layers. *E.g.*, EX1061 at Abstract ("lower TMR" for "CoFe-based junctions" compared to CoFeB); EX1056 ¶¶39 (When the "ferromagnetic layer" is "comprised of a CoFeB alloy," it "exhibits a larger TMR ratio."), 78, 103-04, Fig. 7; EX1024 ¶115.

A skilled artisan would be motivated to increase TMR, which was the driving purpose for most research in this field. EX1062 at 6:14-16 ("What is needed is a method of forming MTJs with *high tunneling magnetoresistance* with improved magnetic switching characteristics."); EX1055 at 2271 ("[A] functioning junction with *high TMR* value means high signal level, high sensitivity, high speed, and lower power consumption for devices based on tunnel junctions."). Thus, a skilled artisan looking to increase TMR would have been motivated to substitute a CoFeB

ferromagnetic layer for Parkin’s reference CoFe ferromagnetic layer based on Wang’s teaching of increased TMR. EX1024 ¶114. Such a “combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results.” *KSR v. Teleflex*, 550 U.S. 398, 416 (2007).

3. Claim 1[b]: “a barrier layer disposed over the first electrode, the barrier layer comprising a magnesium oxide (MgO) layer that is formed of a poly-crystalline MgO in which a (001) crystal plane is preferentially oriented; and”

Parkin disclosed or suggested a polycrystalline MgO barrier layer: “The preferred embodiments and implementations of the invention are directed to MgO or Mg–ZnO tunnel barrier layers which are substantially (100) oriented or textured.” EX1062 at 9:16-18; *see also id.* at 9:58-60 (“Notwithstanding the polycrystalline nature of the film structures described herein, which are in any case preferable for ease of manufacturing....”); EX1024 ¶¶117-22. Because one of skill would recognize that the MgO (001), (100), and (010) planes are equivalent, EX1011 at 4:39-41; EX1024 ¶53, Parkin’s MgO(100) preferentially-oriented layer is the same as a MgO(001) preferentially-oriented layer, EX1024 ¶120.

Particularly, Parkin taught that the Figure 3A embodiment used “highly textured” or polycrystalline MgO: “[V]ery high TMR values are unexpectedly found for MTJs with *highly textured* (100) MgO tunnel barriers but with nominally amorphous storage layers.” EX1062 at 18:49-51; *see also id.* at 18:56 (“cubic

crystalline MgO layer”), 9:19-24 (“[T]unnel barrier layers [that] are polycrystalline” are “what is commonly referred to as textured.”); EX1024 ¶121; *see also* EX1086 at 258-59 (Examiner: Parkin-555 discloses “a polycrystalline magnesium oxide” barrier layer).

Parkin disclosed that in the Figure 3A embodiment, shown below, an **MgO tunnel barrier layer** “120” is then formed on top of the **lower ferromagnetic electrode** 110’.” EX1062 at 17:21-28; EX1024 ¶118. Parkin describes depositing the MgO layer in two steps, first Mg alone followed by MgO, to form a single MgO tunnel barrier layer: “[d]uring the deposition of the MgO layer, the Mg underlayer becomes oxidized so that the two layers form a single MgO tunnel barrier.” EX1062 at 17:35-37; EX1024 ¶119. Parkin also noted that “[t]he exact composition of the MgO layer may differ from the sto[i]chiometric composition” and thus may have oxygen vacancy defects due to the original Mg layer deposited with no oxygen. *Id.* at 17:37-39; EX1024 ¶¶73-74, 119; EX1042 at 161-62; EX1008 (’463 File History) at 198 (oxygen vacancy defects inherent); EX1037 at 3; EX1028 at Abstract, 3232.

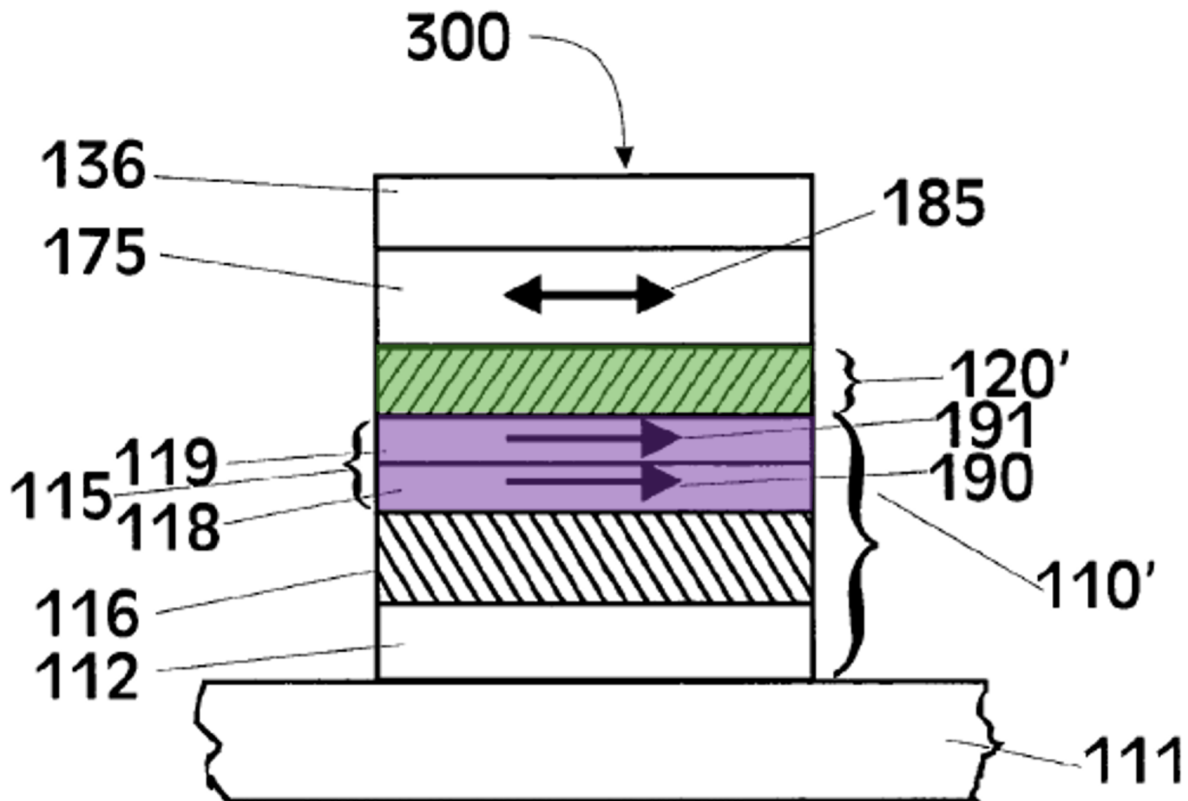


FIG. 3A

EX1062 at Fig. 3A (annotated).

The '138 Patent acknowledges that it was conventional to dispose a tunnel barrier layer over the first ferromagnetic layer in an MTJ. EX1011 at 1:47-51 (Description of Related Art); *id.* at Figs. 8(A)-8(B); EX1045 at 8 (describing “high quality... MgO tunnel barrier”); EX1024 ¶¶31-35, 122.

4. **Claim 1[c]: “a second electrode disposed over the barrier layer and comprising a second ferromagnetic material layer that includes Co, Fe, and B, and”**

This limitation was taught or suggested by Parkin. EX1024 ¶¶123-27.

As specified in this limitation, “second” refers to Parkin’s “**top ferromagnetic electrode**” above the barrier layer. EX1011 at 9:63-65; EX1024 ¶124.

As shown below, Parkin disclosed that after the **MgO tunnel barrier layer** was formed, “the MTJ device shown in FIG. 3A is completed by forming the **top ferromagnetic electrode** which is the storage layer. The storage layer is comprised of an amorphous ferromagnetic layer 175. For example, *the layer 175 may be comprised of 75 Å thick $(\text{Co}_{73}\text{Fe}_{27})_{74}\text{B}_{26}$.*” EX1062 at 17:40-44.

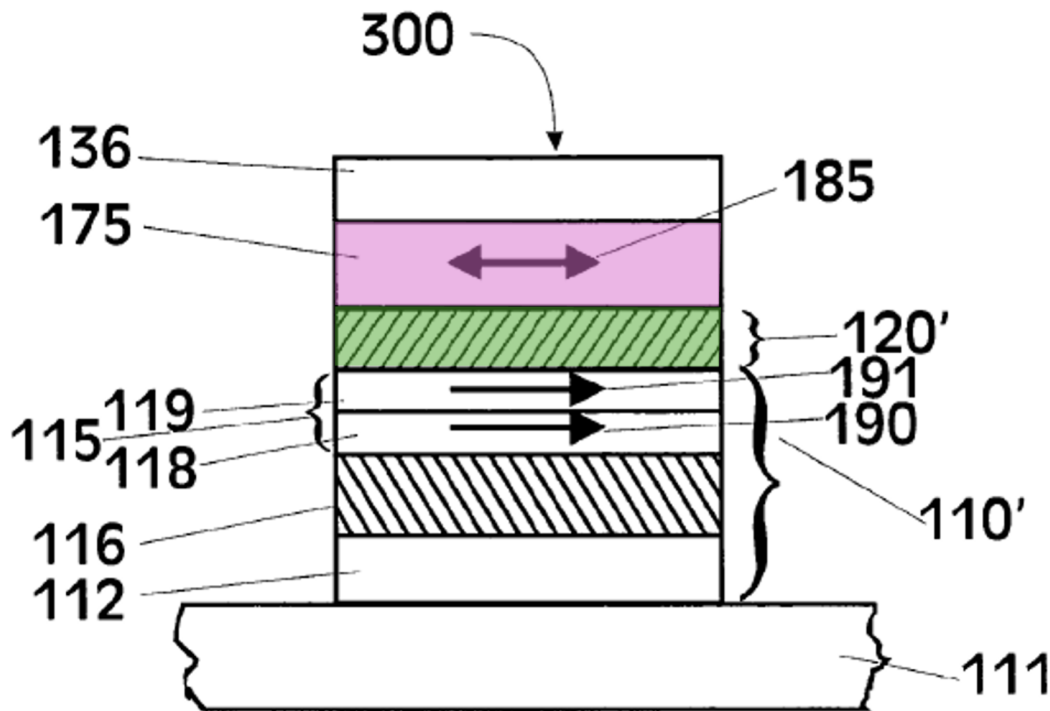


FIG. 3A

EX1062 at Fig. 3A (annotated); EX1024 ¶¶125-26. As explained for Claim 1[a], the claimed “ferromagnetic material layer that includes Co, Fe, and B” is satisfied by any CoFeB alloy. EX1024 ¶126.

Also, as explained for Claim 1[a], MTJs with ferromagnetic layers were conventional. EX1011 at 1:47-51, Figs. 8(A)-8(B); EX1045 at 1; EX1024 ¶¶54-62, 127.

5. Claim 1[d]: “wherein each of the first and second ferromagnetic material layers is entirely crystallized,[] and”

This limitation was taught or suggested by Parkin. EX1024 ¶¶128-36.

Parkin taught that its CoFeB upper ferromagnetic layer 175 was “formed from an amorphous alloy of CoFeB.” EX1062 at 16:47-50. If CoFeB were substituted for the CoFe used in Parkin’s lower “reference” electrode 110’ as explained for Claim 1[a], it would be formed from the same amorphous CoFeB alloy. EX1024 ¶136.

Parkin taught that annealing resulted in an entirely crystallized ferromagnetic layer. Parkin explained that its Figure 3A embodiment showed increased TMR with annealing: “The magnitude of the tunneling magnetoresistance increases with anneal temperature, as shown in more detail in FIG. 5, and reaches a value of nearly 140% after an anneal at 380°C.” EX1062 at 18:13-16; *id.* at 18:45-48 (“TMR values of more than 220% were found after an anneal treatment at 350°C.”), Fig. 5; EX1024 ¶¶129-30. In explaining these “unexpected[]” “very high TMR values,” Parkin taught that “a portion of the storage layer 175 adjacent to the MgO tunnel barrier 120’ has crystallized and is, moreover, textured in the same orientation as the

crystalline MgO tunnel barrier.” EX1062 at 18:51-55. Parkin concludes that “[t]he simple cubic crystalline MgO layer thus provides a template for the formation of a thin crystalline ferromagnetic layer which has the bcc structure of CoFe and is oriented in the same (100) direction as the MgO layer.” *Id.* at 18:55-59; EX1024 ¶131. Others had observed similar results. EX1061 at 2273 (“X-ray measurements... confirmed that the CoFeB films are not amorphous... upon annealing.”); EX1024 ¶134. In short, Parkin’s “thin crystalline ferromagnetic” layer is “entirely crystallized” and forms a CoFeB layer as required by Claim 1[d]. EX1024 ¶132.

A skilled artisan would expect the same effect after annealing the lower electrode if CoFeB were substituted for Parkin’s CoFe ferromagnetic layer 110’ as discussed in Claim 1[a]. EX1024 ¶136.

Parkin’s statement that the crystallized CoFeB layer “has the bcc structure of CoFe” confirms that this layer is crystallized CoFeB: “The highly (100) textured MgO layer is likely to form an excellent template layer for the formation of a thin crystalline layer of CoFeB.” EX1062 at 19:17-19; EX1024 ¶132. Parkin also considers the possibility “that the B diffuses away from the interface with the MgO layer, during the thermal anneal treatments, to leave a thin interface layer at this interface which is much lower in B content.” EX1062 at 19:19-22. Parkin’s “lower”

B content is not zero, meaning that the crystallized layer remains CoFeB. EX1024 ¶¶132-33.

The '138 Patent contains far less disclosure on this subject than Parkin, stating only:

As the amorphous magnetic alloy, FeCoB... may be used, for example. Although an anneal process after the preparation of the MTJ device might cause the amorphous magnetic alloy in the electrode layers to be partially or entirely crystallized, this would not lead to a significant deterioration of the MR ratio. Thus, such a crystallized amorphous magnetic alloy may be used in the electrode layers.

EX1011 at 9:20-27. One of skill would recognize that Parkin teaches or suggests this limitation. EX1024 ¶135; EX1086 at 258-59 (Examiner: Parkin-555 disclosed ferromagnetic material layers that are “partially or entirely crystallized.”).

Indeed, the prior art contains at least as much detail and is of the same character as what IP Bridge accuses of infringement. EX1024 ¶135. For example, in the parallel litigation, IP Bridge asserted that annealed CoFeB ferromagnetic layers and those in which only the CoFeB immediately adjacent to the MgO barrier layer is crystallized are “entirely crystallized.” EX1072 (infringement contentions) at 6-7 (quoting EX1081-EX1083); EX1012 at 200 (Examiner in '138 File History: prior art annealing “would allow the first and second ferromagnetic layers to be

entirely crystallized based on the annealing process”). Thus, IP Bridge concedes that Claim 1[d] is shown by Parkin in view of Wang as discussed above.

6. Claim 1[e]: “wherein a value of x in MgO_x for the MgO layer is greater than 0 and less than 1.”

This limitation was taught or suggested by Parkin. EX1024 ¶¶137-45.

MgO_x with a value of x that is greater than 0 and less than 1 is a mathematical notation indicating a less than one-to-one stoichiometric ratio of oxygen to magnesium, or oxygen vacancy defects, in the MgO layer. EX1024 ¶¶138-39; EX1002 (’403 File History) at 168 (Applicant: “ MgO_x ($0 < x < 1$)” means the MgO “crystals have oxygen vacancy defects.”).

As discussed for Claim 1[b], Parkin taught the formation of an MgO tunnel barrier layer composition (first Mg followed by MgO) that “differ[s] from the sto[i]chiometric composition.” EX1062 at 17:35-39; EX1024 ¶141. Parkin additionally disclosed that its MgO barrier layer in Figure 3A was fabricated using the methods described in Parkin-835 (U.S. Application 10/824,835, EX1092), incorporated by reference into Parkin. EX1062 at 3:24-26 (incorporating Parkin-835), 17:21-28 (describing forming MgO barrier layer using Parkin-835). Parkin-835 taught that “[d]uring the deposition of the layer 124, the Mg layer 122 is exposed to oxygen and will become partially or completely oxidized, depending on the oxidation conditions and the thickness of the Mg layer 122.” EX1092 (Parkin-835)

at 34; EX1024 ¶142. One of skill reading Parkin (via Parkin-835) would recognize that depositing the MgO layer in this manner would result in partially oxidized MgO with oxygen vacancy defects. EX1024 ¶142.

Thus, Parkin at least suggests the formation of an MgO tunnel barrier with oxygen vacancy defects, or where the value of x in MgO_x is $0 < x < 1$. Moreover, all MgO crystalline structures inherently have oxygen vacancy defects. EX1008 ('463 File History) at 198 (Examiner: “It is inherent that the magnesium oxide layer has some level of oxygen vacancy defects.”); EX1024 ¶¶73-82, 140; EX1042 at 161-62; EX1037 at 3; EX1028 at Abstract, 3232.

Additionally, Parkin in view of Soukup also taught or suggested an MgO barrier layer with oxygen vacancy defects. Soukup studied “the effect of nonstoichiometry on the device characteristics,” EX1028 at 3232, and experimented with devices fabricated with different levels of nonstoichiometry, EX1028 at Abstract, 3232-33, Table I; EX1024 ¶144. One of skill would have understood that Parkin’s and/or Soukup’s stoichiometric inhomogeneities in the MgO barrier referred to oxygen vacancy defects in the MgO crystal. EX1011 at 6:32-34, 7:6-14; EX1042 at 162; EX1024 ¶¶73-82, 141-44.

One of skill would also have been motivated to apply Soukup’s teachings about oxygen vacancy defects to Parkin’s MgO MTJ to improve tunneling current,

increase TMR, and enhance MRAM performance for the same reasons as explained in Claim 4. *Infra* §VI.D; EX1024 ¶¶145, 152-66.

B. Claim 2: “The MTJ device of claim 1, wherein the first ferromagnetic material layer is in direct contact with the barrier layer, and wherein the second ferromagnetic material layer is in direct contact with the barrier layer.”

Claim 2 would have been obvious over Parkin in view of Wang and optionally Soukup for the reasons explained for Claim 1. *Supra* §VI.A; EX1024 ¶¶146-48.

As explained for Claims 1[a]-[c], Parkin in view of Wang suggested forming CoFeB layers (the “first” and “second ferromagnetic material layers”) on both sides of, and in direct contact with, the “single MgO tunnel barrier.” EX1062 at 17:35-37; *supra* §§VI.A.2-VI.A.4; EX1024 ¶147. After annealing, this structure would form entirely crystallized CoFeB layers in direct contact with the MgO barrier layer. EX1062 at 18:51-55 (“Cross-section transmission electron microscopy reveals that *a portion of the storage layer 175 adjacent to the MgO tunnel barrier 120’ has crystallized* and is, moreover, textured in the same orientation as the crystalline MgO tunnel barrier.”), 19:17-19 (“The highly (100) textured MgO layer is likely to form an excellent template layer for the formation of a thin crystalline layer of CoFeB.”).

Forming first and second ferromagnetic layers both in direct contact with an MgO barrier layer in an MTJ was conventional. EX1011 at 1:47-51; *id.* at Figs.

8(A)-8(B); EX1045 at 8 (describing “high quality... MgO tunnel barrier”); EX1024 ¶148.

C. Claim 3: “The MTJ device of claim 1, wherein the first ferromagnetic material layer is in direct contact with the MgO layer, and wherein the second ferromagnetic material layer is in direct contact with the MgO layer.”

Claim 3 was obvious over Parkin in view of Wang and optionally Soukup for the reasons explained for Claim 2. *Supra* Claims 1-2, §§VI.A-VI.B; EX1024 ¶¶149-50.

D. Claim 4: “The MTJ device of claim 1, wherein a barrier height ϕ of the barrier layer is in a range of 0.2 to 0.5 eV.”

Claim 4 would have been obvious over Parkin in view of Wang and Soukup. EX1024 ¶¶151-67; *supra* §VI.A (Claim 1). The tunnel barrier height measures the difference between the Fermi level of the electrode and the bottom of the conduction band of the barrier layer. EX1031 at Fig. 1; EX1024 ¶¶45-49, 152.

These references taught or suggested a tunnel barrier height for an MgO barrier layer in the disclosed range of 0.2 to 0.5 eV. EX1024 ¶152. Parkin taught or suggested lowering the barrier height for electrons to facilitate tunneling, describing a polycrystalline MgO layer where “the arrangement of atoms in a bcc structure oriented in the (100) direction with respect to the direction of tunneling.” EX1062 at 14:38-41, Fig. 2; *see id.* at 15:26-34; EX1024 ¶153. Soukup observed a “barrier

height” within the disclosed range of “*about 0.33 eV*” for its MgO barrier. EX1028 at Abstract; *id.* at 3231-32, Fig. 5, Table I; EX1024 ¶154.

Soukup taught that oxygen vacancy defects had an impact on the barrier height for MgO. EX1024 ¶155. 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 ¶155. 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 an inverse relationship between oxygen vacancy defects and barrier height. EX1024 ¶155.

One of skill 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 Parkin’s MgO barrier as modified by Wang. EX1028 at Abstract, 3232, 3236; EX1024 ¶¶156-58. According to the equation for TMR, lowering the resistance for parallel electrons (R_p) compared to anti-parallel electrons (R_{ap}) would improve TMR. EX1035 at 3273; EX1027 ¶2; EX1044 at 1-9; EX1045 at 1; EX1011 at 4:64-5:3; EX1024 ¶156 (explaining that lowering barrier height can decrease R_p relative to R_{ap} due to the lack of band matching in the anti-parallel electrodes). TMR was an “important parameter” for improving MRAM performance. EX1062 at 6:14-16 (“What is needed is a method of forming MTJs with *high tunneling magnetoresistance* with

improved magnetic switching characteristics.”); EX1055 at 2269, 2271 (“[A] functioning junction with *high TMR* value means high signal level, high sensitivity, high speed, and lower power consumption for devices based on tunnel junctions.”); EX1049 at 185-88, 194; EX1044 at 1; EX1045 at 1; EX1046 at 1; EX1035 at 3273; EX1027 ¶2; EX1024 ¶¶31-35, 157-58. Skilled artisans, including Parkin, had long been interested in increasing TMR to enable better-performing MRAM. EX1062 at 2:25-64 (describing the history of improvements in TMR for MTJs), 2:65-3:1 (“[H]igh TMR values are needed for improving the performance of” MRAM or magnetic recording heads.); EX1055 at 2271; EX1024 ¶¶36-44, 157-58.

Butler and Mathon 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. EX1044 at 1; EX1046 at 1; EX1024 ¶157. Parkin cited to Butler and referenced these earlier “[t]heoretical predictions of high TMRs in MTJs.” EX1062 at page 2, 15:26-34; EX1024 ¶157. One of skill in the art looking to increase TMR of an MgO barrier would have been motivated to explore lower barrier heights to facilitate tunneling of parallel electrons. EX1024 ¶158. Thus, one of skill seeking to improve Parkin’s MgO MTJ would have looked to Soukup’s teachings about MgO barriers and how defects lowered the barrier height. *Id.* Indeed, both Parkin and Soukup studied properties of MgO barriers and were

focused on improving tunneling devices, the problem to which the '138 Patent was directed. EX1062 at 6:14-16 (“What is needed is a method of forming MTJs with *high tunneling magnetoresistance* with improved magnetic switching characteristics.”); EX1028 at 3229-30; EX1011 at Abstract, 1:32-2:29; EX1024 ¶158.

One of skill would have had a reasonable expectation of success in achieving a tunnel barrier height in the claimed range in Parkin’s MTJ. EX1024 ¶159. Soukup fabricated an MgO barrier that achieved a height of 0.33 eV, EX1028 at Abstract, and one of skill in the art would have been motivated to achieve Soukup’s barrier height in an MgO MTJ to improve tunneling and hence TMR, EX1028 at Abstract, 3232, 3236; EX1024 ¶¶159, 161. One of skill would have predictably followed the trail blazed by Parkin and Soukup. EX1024 ¶159.

The claimed tunnel barrier height range of 0.2 to 0.5 eV also would have been within the knowledge of those skilled in the art. EX1024 ¶160. The claimed range is only slightly below the barrier height of “0.9 eV” taught by Bowen and others. EX1026 at 1656 (citing EX1038); EX1038 at 4725-26; EX1024 ¶160. One of skill would have been aware that oxygen vacancy defects impacted the barrier height. Bowen, for example, hypothesized that the low barrier height they observed, which was “lower than half” of the calculated value for “an ultrathin layer” of MgO, may have been due to the “presence of stoichiometric... inhomogeneities in the insulating

film.” EX1026 at 1656; EX1024 ¶161. 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. EX1024 ¶¶163-66.

IP Bridge itself concedes this limitation is obvious. The ’138 Patent 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.” EX1011 at 7:7-11. Thus, according to the ’138 Patent, the tunnel barrier height limitation is inherent when there are oxygen vacancy defects as disclosed by Soukup. EX1026 at 1656; EX1028 at 3232, 3236; EX1024 ¶162.

IP Bridge is no longer defending the patentability of this limitation. The Examiner recently rejected two applications, finding “Kishi teaches a barrier height of (0.1 eV to 0.85 eV) and (.2eV to .5eV).” EX1086 at 228, 257; EX1087 at 199-200. IP Bridge responded by abandoning both applications in January 2025. EX1086 at 262-63; EX1087 at 207-08; *supra* §II.D.

Further, in the co-pending litigation, IP Bridge asserted that this limitation is met by the mere “presence of oxygen vacancy defects.” EX1064 at 19 (citing EX1001 at 6:47-7:2). Thus, this limitation is satisfied. *Spectrum Sols. v. Longhorn Vaccines*, IPR2021-00847, Paper 13 at 23 (P.T.A.B. Nov. 12, 2021) (ordering institution).

E. Claim 7

Claim 7 would have been obvious over Parkin in view of Wang and optionally Soukup. EX1024 ¶¶168-75.

1. Claim 7[preamble]: “A magnetic tunnel junction (MTJ) device, comprising:”

Supra Claim 1[preamble], §VI.A.1; *see also infra* Claims 7[a]-7[f], §§VI.E.2-VI.E.7; EX1024 ¶168.

2. Claim 7[a]: “a first electrode made of a first CoFeB layer;”

As explained, one of skill would have understood that an electrode made of a CoFeB layer referred to the same alloy as a ferromagnetic layer including Co, Fe, and B. *Supra* Claim 1[a], §VI.A.2; EX1024 ¶169.

3. Claim 7[b]: “a barrier layer made of a magnesium oxide (MgO) layer that is a poly-crystalline layer in which a (001) crystal plane is preferentially oriented; and”

Supra Claim 1[b], §VI.A.3; EX1024 ¶170.

4. **Claim 7[c]: “a second electrode made of a second CoFeB layer, and”**

Supra Claims 1[c], 7[a], §§VI.A.4, VI.E.2; EX1024 ¶171.

5. **Claim 7[d]: “wherein the barrier layer is located between the first electrode and the second electrode, and”**

As explained, Parkin’s MgO barrier layer 120’ was located between its lower electrode 115 and upper electrode 175:

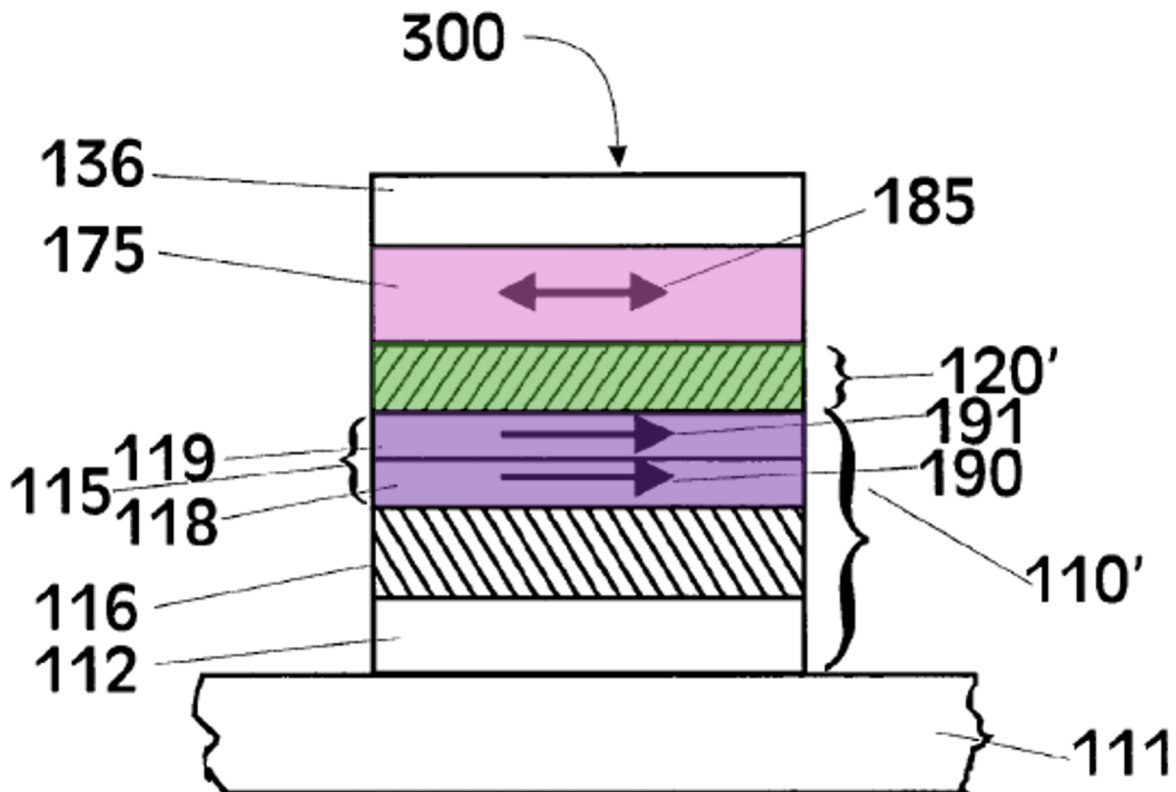


FIG. 3A

EX1062 at Fig. 3A (annotated); *supra* Claims 1[a]-1[c], 2-3, §§VI.A.2-VI.A.4, VI.B-VI.C; EX1024 ¶¶172-73.

6. **Claim 7[e]: “wherein both the first and second CoFeB layers are entirely crystallized, and”**

Supra Claim 1[d], §VI.A.5; EX1024 ¶174.

7. **Claim 7[f]: “wherein a value of x in MgO_x for the MgO layer is greater than 0 and less than 1.”**

Supra Claim 1[e], §VI.A.6, EX1024 ¶175.

- F. **Claim 8: “The MTJ device of claim 7, wherein the first CoFeB layer is in direct contact with the MgO layer, and wherein the second CoFeB layer is in direct contact with the MgO layer.”**

Claim 8 would have been obvious over Parkin in view of Wang and optionally Soukup. *Supra* Claims 2-3, and 7, §§VI.B-VI.C, VI.E; EX1024 ¶176.

- G. **Claim 9: “The MTJ device of claim 7, wherein the MgO layer and the first CoFeB layer form a first interface of the MTJ, and wherein the MgO layer and the second CoFeB layer form a second interface of the MTJ.”**

Claim 9 would have been obvious over Parkin in view of Wang and optionally Soukup. EX1024 ¶¶177-79; *supra* §§VI.B, VI.C, VI.E (Claims 2-3, 7).

“Interface” refers to the boundary between two materials, which in the context of Claim 9 is the boundary between the MgO layer and the first CoFeB layer, and the boundary between the MgO layer and the second CoFeB layer. EX1011 at 1:53-64 (Description of Related Art); *id.* at Figs. 8(A)-(B); *see also id.* at 5:47-51; EX1024 ¶178.

Parkin teaches or suggests both the “**first**” and “**second**” interfaces:

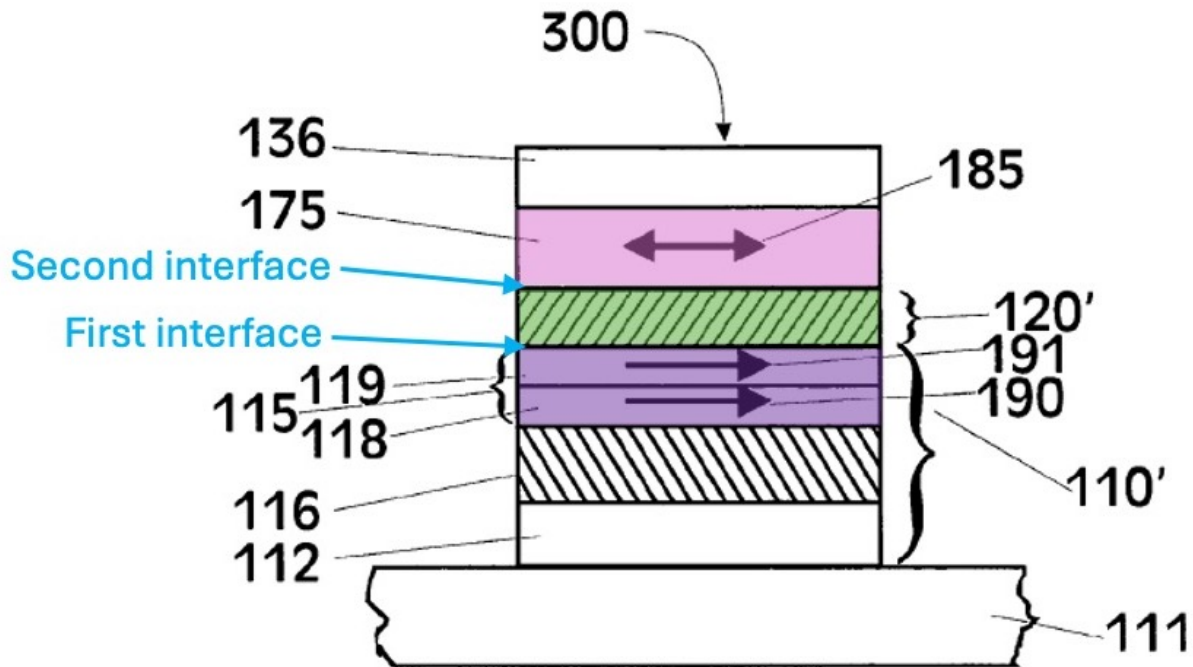


FIG. 3A

EX1062 at Fig. 3A (annotated). Parkin discusses the importance of the “interface between the ferromagnetic electrode and tunnel barrier,” EX1062 at 11:64-67; 11:21-64, 19:6-27, explaining that TMR magnitude is “extremely sensitive to the nature of the interface between the tunneling barrier and the ferromagnetic electrode,” EX1062 at 11:49-52, 11:64-67; EX1024 ¶179.

H. Claim 10: “The MTJ device of claim 7, wherein a barrier height ϕ of the MgO layer is in a range of 0.2 to 0.5 eV.”

Claim 10 would have been obvious over Parkin in view of Wang and Soukup.

Supra Claims 4 and 7, §§VI.D, VI.E; EX1024 ¶180.

I. Claim 12

Claim 12 would have been obvious over Parkin in view of Wang and optionally Soukup. EX1024 ¶¶181-85.

1. Claim 12[preamble]: “A magnetic tunnel junction (MTJ) device, comprising:”

Supra Claim 1[preamble], §VI.A.1; *see also infra* Claims 12[a]-[d], §§VI.I.2-VI.I.5; EX1024 ¶181.

2. Claim 12[a]: “a first ferromagnetic material layer that includes Co, Fe, and B;”

Supra Claim 1[a], §VI.A.2; EX1024 ¶182.

3. Claim 12[b]: “a barrier layer disposed on the first ferromagnetic material layer, the barrier layer comprising a magnesium oxide (MgO) layer that is a poly-crystalline MgO in which (001) crystal plane is preferentially oriented; and”

Supra Claim 1[b], §VI.A.3; EX1024 ¶183.

4. Claim 12[c]: “a second ferromagnetic material layer that is disposed on the barrier layer and includes Co, Fe, and B, and”

Supra Claim 1[c], §VI.A.4; EX1024 ¶184.

5. Claim 12[d]: “wherein each of the first and second ferromagnetic material layers is entirely crystallized, and wherein a value of x in MgO_x for the MgO layer is greater than 0 and less than 1.”

Supra Claims 1[d]-1[e], §§VI.A.5-VI.A.6; EX1024 ¶185.

J. Claim 13: “The MTJ device of claim 12, wherein a barrier height ϕ of the barrier layer is in a range of 0.2 to 0.5 eV.”

Claim 13 would have been obvious over Parkin in view of Wang and Soukup.

Supra Claims 4 and 12, §§VI.D, VI.I; EX1024 ¶186.

VII. GROUND 2: CLAIMS 5-6, 11, AND 14 ARE OBVIOUS OVER PARKIN IN VIEW OF WANG, SOUKUP, AND BOWEN

Claims 5-6, 11, and 14 would have been obvious over Parkin in view of Wang, Soukup, and Bowen. EX1024 ¶¶187-241.

A. Claim 5

1. Claim 5[preamble]: “The MTJ device of claim 4,”

Supra Claims 1[preamble] and 4, §§VI.A.1, VI.D; EX1024 ¶188.

2. Claim 5[a]: “wherein the barrier height ϕ of the barrier layer is obtained by fitting J-V characteristics of the MTJ device to an equation (1): $J = [(2m\phi)^{1/2} / \Delta s] (e/h)^2 \times \exp[-(4\pi\Delta s/h) \times (2m\phi)^{1/2}] \times V$ (1)”

This limitation is taught or suggested by Soukup and Bowen. EX1024 ¶¶189-201.

Claim 5[a] specifies a tunnel “barrier height ϕ ” obtained by fitting the J-V characteristics of a tunnel barrier junction to Simmons’ formula: “an equation (1): $J = [(2m\phi)^{1/2} / \Delta s] (e/h)^2 \times \exp[-(4\pi\Delta s/h) \times (2m\phi)^{1/2}] \times V$.” EX1011 at 10:13-17.

It was widely known that tunnel barrier height can be calculated using Simmons’ corrected formula. “[E]quation (1)” is Simmons’ corrected formula from his 1963 paper for calculating tunnel barrier height. *Compare* EX1011 at 10:17

(Claim 5[a]), *with* EX1031 at 1796-97 (Simmons' Equation (25)); EX1059 at 1; EX1011 at 7:27-40, 7:55-66; EX1024 ¶¶190-95. The tunnel barrier height is conventionally determined by fitting the barrier's J-V curves to Simmons' formula. EX1031 at 1796 (“[I]f the current-voltage characteristic of a tunnel junction is known, the mean barrier height can be determined.”); EX1026 at 1656, 1657 n.13; EX1028 at 3229, 3236 n.1; EX1035 at 3274, 3276 n.16; EX1053 at 8042, 8043 n.14; EX1024 ¶195. IP Bridge agrees. *E.g.*, EX1074 at 5, 14-15 (acknowledging “equation (1)” is “Simmons' formula” in this limitation).

Bowen taught using Simmons' formula to approximate its tunnel barrier height. He used “I(V) curves [to] place[] the barrier height at $\phi=0.9$ eV” at 10 mV for his Fe/MgO/FeCo MTJ. EX1026 at 1656. He compared his measurements with “Simmons' equations” and cited to Simmons' foundational 1963 paper. EX1026 at 1656, 1657 n.13 (citing EX1031); EX1024 ¶196. Soukup recognized “Simmons' model” was used to evaluate the “height and the bias dependence of the insulator potential-energy barrier.” EX1028 at 3229, 3236 n.1 (citing EX1031); EX1024 ¶197.

One of skill would have found it obvious to use Bowen's teaching of applying Simmons' formula to calculate the “barrier height ϕ ” in Parkin's MgO MTJ as modified by Wang and Soukup. EX1024 ¶198. One of skill would have found it useful to attempt to quantify and also benchmark MTJ performance in terms of

barrier height. EX1024 ¶198. Simmons' equation was an accepted method in the field for calculating barrier height as taught by Bowen and Soukup, and Bowen expressly taught the use of Simmons' equation to calculate barrier height of an MTJ. EX1024 ¶¶196-98; EX1026 at 1656, 1657 n.13.

One of skill would have also looked to Bowen's teachings about Simmons' equation to apply them to Parkin's MTJ because both Bowen and Parkin focused on improving the TMR of magnetoresistive devices, a problem to which the '138 Patent is directed. EX1026 at Abstract, 1655; EX1062 at 1:18-21 (“[T]his invention relates to an improved MTJ exhibiting high tunneling magnetoresistance....”); EX1011 at 1:32-35 (“The present invention relates to a... magnetic tunnel junction device with a high magnetoresistance and a method of manufacturing the same.”), 2:35-39 (describing need for better MTJs to improve MRAM); EX1024 ¶¶199-200. Both were directed to improving MRAM memory performance, as was the '138 Patent. EX1026 at 1655; EX1062 at 2:65-3:1 (“[F]or non-volatile magnetic memory storage cells, high TMR values are needed for improving the performance of these devices.”); EX1011 at 2:57-60; EX1024 ¶200.

Because it was well known that the barrier height of an MgO MTJ could be described using Simmons' equation, one of skill would have found calculating the barrier height to be a straightforward, predictable, and desirable exercise. EX1024 ¶201.

3. **Claim 5[b]: “where J is a tunnel current density flowing through the barrier layer, V is an applied bias voltage that is 100 mV or smaller, m is the free electron mass, e is the elementary electric charge, h is Planck’s constant, Δs is an effective thickness of the barrier layer that is equivalent to $(t_{\text{MgO}} - 0.5 \text{ nm})$, and t_{MgO} is an actual thickness of the barrier layer.”**

Claim 5[b] specifies the variables and some specific values for those variables in Simmons’ formula. EX1011 at 10:18-24; EX1024 ¶202. Each were taught or suggested by Soukup and Bowen. EX1024 ¶¶202-11.

The ’138 Patent uses the same variables from Simmons’ foundational paper as shown in the table below:

Claim 5[b] limitations [EX1011 at 10:18-24]	Simmons’ formula (1963) [EX1031 at 1794]
“ J is a tunnel current density”	“ J =tunnel current density”
“ V is an applied bias voltage”	“ V =voltage across film”
“ m is the free electron mass”	“ m =mass of electron”
“ e is the elementary electric charge”	“ e =charge of electron”
“ h is Planck’s constant”	“ h =Planck’s constant”
“ Δs is an effective thickness of the barrier layer”	“ $\Delta s = s_2 - s_1$ ”

Compare EX1011 at 10:18-24, with EX1031 at 1794 (defining variables); EX1024 ¶204.

Calculating a barrier height using the variables in Simmons’ formula would have been obvious. EX1024 ¶¶203-10. Indeed, Simmons’ 1963 paper told one of

skill how to calculate barrier height in exactly this manner. EX1031 at 1794-97; EX1024 ¶203. As explained for Claim 5[a], Soukup observed Simmons' formula was used to calculate barrier height. *Supra* §VII.A.2; EX1024 ¶¶195, 197-98.

None of the requirements of Claim 5[b] are inventive:

Claim 5[b] recites that “J is a tunnel current density flowing through the barrier layer.” EX1011 at 10:18-19. One of skill would understand the '138 Patent is restating Simmons' variable: “J=tunnel current density.” EX1031 at 1794; EX1024 ¶206. Simmons explained that “[t]he purpose of this paper is to derive a single theory for the *current flow through a generalized barrier*.” EX1031 at 1794; EX1024 ¶206.

Claim 5[b] further recites: “V is an applied bias voltage that is 100 mV or smaller.” EX1011 at 10:19-20. Applying a low voltage of under 100 mV would have been obvious. Indeed, Simmons provided the equation (25) recited in Claim 5[a] for a “Low-Voltage Range: $V \approx 0$ ” for “low voltages.” EX1031 at 1797; EX1024 ¶208. “100 mV or smaller” (i.e., ≤ 0.1 V) is a low voltage. EX1024 ¶208. Skilled artisans understood that applying Simmons' equation required using low voltages. For example, Bowen measured the barrier height “at 10 mV.” EX1026 at 1656. As shown in Figure 3, Bowen also applied various bias voltages to its MTJ to measure TMR, including spanning -1 V to +1.4 V, finding the highest TMR “value of 60% at 10 mV.” EX1026 at Fig. 3, 1657; EX1024 ¶207.

This limitation also requires: “ Δs is an effective thickness of the tunnel barrier layer that is equivalent to $(t_{\text{MgO}} - 0.5 \text{ nm})$.” EX1011 at 10:21-23. One of skill would understand that Simmons’ Δs variable is an “effective thickness”; he defined it as “ $\Delta s = s_2 - s_1$ ” where “ s_1, s_2 = limits of barrier at Fermi level.” EX1031 at 1794; EX1024 ¶209.

Having a tunnel barrier layer with an effective thickness “that is equivalent to $(t_{\text{MgO}} - 0.5 \text{ nm})$ ” was suggested by Bowen. EX1024 ¶210. According to Claim 5[b], “ t_{MgO} is an actual thickness of the barrier layer.” EX1011 at 10:23-24; *see also* EX1031 at 1794 (“ s = thickness of insulating film”); EX1024 ¶210. Bowen taught an effective thickness of the barrier of 0.5 nm less than the actual barrier thickness. He fabricated an Fe/MgO/FeCo MTJ with an MgO barrier of “20 Å” or 2 nm. EX1026 at 1656; EX1024 ¶210. He used Simmons’ equations to calculate “a barrier thickness $d \sim 15 \text{ Å}$,” or 1.5 nm, for his MTJ. *Id.* Bowen’s calculated effective thickness of 1.5 nm was 0.5 nm less than the 2 nm actual thickness. *See id.*

B. Claim 6: “The MTJ device of claim 1, wherein a value of x in MgO_x for the MgO layer is greater than 0.9 and less than 1.”

Claim 6 would have been obvious over Parkin in view of Wang, Soukup, and Bowen. EX1024 ¶¶212-34; *supra* §VI.A (Claim 1). One of skill would have combined these references as explained in Claim 5[a] as they were all directed to improving TMR of magnetoresistive devices. *Supra* §VII.A.2. Oxygen vacancy

defects between 0.9 and 1 for an MgO barrier were known. *E.g.*, EX1037 at 3; EX1024 ¶¶213-14.

Additionally, the claimed “value of x in MgO_x” in a range “greater than 0.9 and less than 1” range was a result-effective variable within a skilled artisan’s grasp and achievable through routine optimization. *In re Applied Materials*, 692 F.3d 1289, 1295 (Fed. Cir. 2012). Indeed, the Examiner recognized that it “would have been obvious to one having ordinary skill in the art at the time the invention was made to optimize the oxygen deficiency.” EX1016 (’372 File History) at 91.

The ’138 Patent disclosed that the claimed invention was directed to an MTJ device with a high TMR. EX1011 at 1:32-35, 2:57-60, 4:64-5:3 (disclosing the equation for determining the “magnetoresistance (MR) ratio of a MTJ device”); *supra* §II.C. By the ’138 Patent’s priority date, skilled artisans, including Parkin, were already interested in increasing TMR to enable better performing MRAM, as explained for Claims 1[e] and 4. EX1062 at 6:14-16 (“What is needed is a method of forming MTJs with **high tunneling magnetoresistance** with improved magnetic switching characteristics.”); EX1044 at 1; EX1045 at 1; EX1046 at 1; EX1055 at 2269, 2271 (“[A] functioning junction with **high TMR** value means high signal level, high sensitivity, high speed, and lower power consumption for devices based on tunnel junctions.”); EX1024 ¶¶36-44, 215-18; *supra* §§VI.A.6, VI.D. To that end, researchers had studied achieving higher TMR using MgO barrier layers and

the impact of oxygen vacancy defects on MgO barrier height. EX1044 at 1; EX1046 at 1, Fig. 16; EX1026 at Abstract, 1655-57; EX1028 at 3229-30; EX1024 ¶¶73-82, 219, 230. Consequently, there was already a recognition in the prior art of the relationship between MgO oxygen vacancy defects, MgO barrier height, and increasing TMR, indicating that this limitation was a result-effective variable. *E.I. DuPont v. Synvina C.V.*, 904 F.3d 996, 1009 (Fed. Cir. 2018) (“[I]f the prior art does recognize that the variable affects the relevant property or result, then the variable is result-effective.... ‘[T]he prior art need not provide the exact method of optimization for the variable to be result-effective.’” (citation omitted)).

Because “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.” *DuPont*, 904 F.3d at 1006 (citation omitted). As discussed in Claim 1[e] of Ground 1, Parkin taught or suggested oxygen vacancy defects in its MgO barrier. EX1062 at 17:35-39; EX1092 at 34; EX1024 ¶¶141-42, 227; *supra* §VI.A.6. Soukup also directly studied the “effect of nonstoichiometry on the device characteristics,” EX1028 at 3232, and experimented with devices fabricated with different levels of nonstoichiometry, *id.* at Abstract, 3232-33, Table I; EX1024 ¶219. As explained in Claim 1[e], MgO with oxygen vacancy defects is inherently MgO_x where x is greater than 0 and less than 1. *Supra* §VI.A.6; EX1024 ¶140. Thus, MgO_x where x is greater than 0.9 and less than 1 is merely a subrange within that

which is disclosed or suggested by Parkin and Soukup and is thus overlapping. *DuPont*, 904 F.3d at 1006 (“We have said that [the ranges of a claimed composition overlapping the ranges disclosed in the prior art] creates a presumption of obviousness.”).

The '138 Patent disclosed two MTJ device embodiments. EX1024 ¶¶220-25. The first embodiment, the “MgO(001) barrier layer 21,” was deposited using “electron-beam evaporation” “under ultrahigh vacuum of 10^{-9} Torr,” or 1.33×10^{-7} Pa. EX1011 at 6:24-32, 6:38-42, 6:56-58; EX1024 ¶¶220-21. This first MTJ device embodiment reportedly yielded a TMR of about 88% at room temperature, EX1011 at 8:4-8, Fig. 6; EX1024 ¶222, wherein there was the “possibility” that the MgO layer had oxygen vacancy defects “such as MgO_x ($0.9 < x < 1$),” EX1011 at 7:6-7, Fig. 5; EX1024 ¶223.

The MgO layer of the second “Fe(001)/MgO(001)/Fe(001) MTJ device” in the '138 Patent was “deposited in a poly-crystalline or amorphous state by sputtering or the like.” EX1011 at 8:43-47; EX1024 ¶224. While not disclosed, one of skill would understand that because sputtering occurred “in an Ar atmosphere” and oxygen was not introduced, the MgO layer was deposited under a “high vacuum” of “on the order of no more than 10^{-6} Pa.” EX1011 at 8:54, 9:38-40; EX1024 ¶¶224-25. TMR and the quantity of the oxygen vacancy defects were not specifically disclosed. *See generally* EX1011.

Parkin's, Bowen's, and Soukup's MgO barrier fabrication methods comprised the general acceptable conditions according to the '138 Patent's disclosure, recognizing "it should be obvious that" either electron-beam evaporation or sputtering were possible MgO deposition methods, EX1011 at 9:35-38, indicating the deposition method was not inventive, EX1024 ¶226; *DuPont*, 904 F.3d at 1006.

Parkin's MgO layer was deposited using "reactive magnetron sputtering using an argon-oxygen plasma containing 3 atomic percent oxygen." EX1062 at 17:33-35; *see also id.* 8:21-27 (manufacturing MgO layer "using standard deposition techniques"); EX1024 ¶227. Moreover, Parkin-835 expressly disclosed that "depending on the oxidation conditions and the thickness of the Mg layer 122," the "Mg layer 122 is exposed to oxygen and will become *partially or completely oxidized*." EX1092 at 34; *see also* EX1062 at 3:24-26 (incorporating Parkin-835 by reference).

Bowen's MgO layer was deposited using sputtering, like the '138 Patent's second MTJ device embodiment. EX1011 at 8:43-48; EX1026 at 1655; EX1024 ¶228. Soukup's MgO layer was deposited using electron-beam evaporation, like the '138 Patent's first MTJ device embodiment. EX1028 at 3230; EX1011 at 6:7-14, 6:38-42; EX1024 ¶229.

While Parkin, Bowen, and Soukup did not expressly quantify the oxygen vacancy defects in their respective MgO layers, as explained in Claim 1[e] of

Ground 1, one of skill would have understood that oxygen vacancy defects necessarily resulted in an MgO_x barrier layer where x is greater than 0 and less than 1, EX1024 ¶¶73-82, 230, that these defects impacted the barrier height, EX1028 at Abstract, 3232; EX1026 at 1656; EX1024 ¶230, and that reducing the barrier height was desirable for achieving higher TMR, EX1044 at 1; EX1045 at 1; EX1046 at 1; EX1024 ¶¶155-58, 230.

Oxygen vacancy defects are obvious as a result-effective parameter. *E.g.*, *Pfizer v. Sanofi Pasteur*, 94 F.4th 1341, 1348 (Fed. Cir. 2024). Moreover, Soukup’s barrier height of 0.33 eV was within the range disclosed by the ’138 Patent as indicative of “oxygen vacancy defects.” EX1028 at Abstract; EX1011 at 7:7-14; EX1024 ¶233. Thus, according to the ’138 Patent, its claimed oxygen vacancy defect ranges are inherent in Soukup. *See Arbutus Biopharma v. ModernaTX*, 65 F.4th 656, 662 (Fed. Cir. 2023).

Additionally, the ’138 Patent did not disclose that the effect of oxygen vacancy defects generally, or specifically, in the claimed range of “greater than 0.9 and less than 1,” was somehow new or unexpected. *See* EX1011 at 6:63-7:26. The ’138 Patent did not identify anything inventive about its MgO layer deposition methods, EX1011 at 9:35-38; EX1024 ¶231, and disclosed that obtaining oxygen vacancy defects could be introduced by standard methodologies, EX1011 at 8:61-67. None

of these methods were identified as inventive or unexpectedly leading to higher-than-expected performance. *See* EX1011 at 8:61-67; *DuPont*, 904 F.3d at 1006.

Indeed, the '138 Patent's own disclosure indicates the "greater than 0.9 and less than 1" claimed range is not critical. *DuPont*, 904 F.3d at 1006. The claimed range is, in fact, speculative: "Since the separated oxygen is pumped out of the deposition chamber using vacuum pumps, there is the *possibility* that there are oxygen vacancy defects *such as* MgO_x ($0.9 < x < 1$).” EX1011 at 7:4-7; EX1024 ¶232. The specification also conceded that MgO layer oxygen vacancy defects were not required, disclosing that “the height of the tunnel barrier may be adjusted by doping Ca or Sr, *instead* of introducing an [sic] oxygen vacancy defects to the MgO layer.” EX1011 at 9:33-9:35; EX1024 ¶234.

Because Claim 6 was disclosed or suggested by Parkin in view of Wang, Soukup, and Bowen, and also is obvious as a result-effective variable that was not critical to the claimed invention and achievable by routine optimization, it is obvious.

C. Claim 11

1. Claim 11[preamble]: “The MTJ device of claim 10,”

Supra Claims 1[preamble], 10, §§VI.A.1, VI.H; EX1024 ¶235.

2. **Claim 11[a]: “wherein the barrier height ϕ of the MgO layer is obtained by fitting J-V characteristics of the MTJ device to an equation (1): $J=[(2m\phi)^{1/2}/\Delta s](e/h)^2 \times \exp[-(4\pi\Delta s/h) \times (2m\phi)^{1/2}] \times V$ (1)”**

Supra Claim 5[a], §VII.A.2; EX1024 ¶236.

3. **Claim 11[b]: “where J is a tunnel current density flowing through the MgO layer, V is an applied bias voltage that is 100 mV or smaller, m is the free electron mass, e is the elementary electric charge, h is Planck’s constant, Δs is an effective thickness of the MgO layer that is equivalent to ($t_{\text{MgO}}-0.5$ nm), and t_{MgO} is an actual thickness of the MgO layer.”**

Supra Claim 5[b], §VII.A.3; EX1024 ¶237.

D. Claim 14

1. **Claim 14[preamble]: “The MTJ device of claim 13,”**

Supra Claims 1[preamble], 13, §§VI.A.1, VI.J; EX1024 ¶238.

2. **Claim 14[a]: “wherein the barrier height ϕ of the barrier layer is obtained by fitting J-V characteristics of the MTJ device to an equation (1): $J=[(2m\phi)^{1/2}/\Delta s](e/h)^2 \times \exp[-(4\pi\Delta s/h) \times (2m\phi)^{1/2}] \times V$ (1)”**

Supra Claim 5[a], §VII.A.2; EX1024 ¶239.

3. **Claim 14[b]: “where J is a tunnel current density flowing through the barrier layer, V is an applied bias voltage that is 100 mV or smaller, m is the free electron mass, e is the elementary electric charge, h is Planck’s constant, Δs is an effective thickness of the barrier layer that is equivalent to ($t_{\text{MgO}}-0.5$ nm), and two [sic] is an actual thickness of the barrier layer.”**

Supra Claim 5[b], §VII.A.3; EX1024 ¶¶240-41.

Claim 14[b] includes a printing error. EX1024 ¶241. The claim recites “*two* is an actual thickness of the barrier layer.” EX1011 at 11:19-20. However, the allowed claims instead specified “*t_{MgO}* is an actual thickness of the barrier layer.” EX1012 at 356-57 (application claim 26 in 5/20/2019 amendment), 360 (allowing amendment).

VIII. GROUND 3: CLAIMS 1-14 ARE OBVIOUS OVER BOWEN IN VIEW OF WANG AND SOUKUP

All Claims 1-14 would have been obvious over Bowen in view of Wang and Soukup, with Soukup optional in the combinations for Claims 1-3, 7-9, and 12. EX1024 ¶¶242-367.

A. Claim 1

1. Claim 1[preamble]

To the extent limiting, Bowen disclosed or suggested an MTJ device as claimed. *E.g.*, EX1026 at 1655-56 (discussing FeCo/MgO/Fe MTJ epitaxial structure), Abstract, Fig. 1; EX1024 ¶¶243-46; *see infra* §§VIII.A.2-VIII.A.6.

The '138 Patent acknowledges that MTJs were well known. EX1024 ¶¶31-35, 246; *supra* § VI.A.1 (Ground 1, Claim 1[preamble]).

2. Claim 1[a]

This limitation was taught or suggested by Bowen in view of Wang. EX1024 ¶¶247-58.

As explained, “first” refers to the “lower” ferromagnetic electrode positioned below the tunnel barrier layer. *Supra* §§II.B, VI.A.2 (Ground 1, Claim 1[a]); EX1024 ¶¶248-49. Ferromagnetic layers in MTJs were conventional. *Supra* §VI.A.2 (Ground 1, Claim 1[a]); EX1024 ¶¶54-62, 251. Claim 1[a] does not require any specific molecular composition of the ferromagnetic layer including Co, Fe, and B, and thus CoFeB satisfies it. *Supra* §VI.A.2 (Ground 1, Claim 1[a]); EX1024 ¶252.

Bowen disclosed that its “Fe(200 Å)” of its “Fe(200 Å)/MgO(20 Å)/FeCo(250 Å) trilayer” was the “first ferromagnetic material layer.” EX1026 at 1655-56

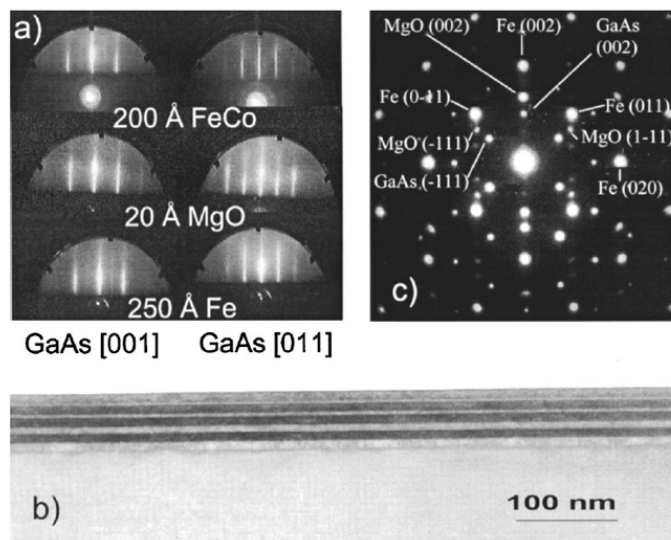


FIG. 1. (a) RHEED patterns along the GaAs [100] and [110] substrate azimuths of a typical FeCo/MgO/Fe epitaxial structure; (b) cross section TEM image of a Fe/MgO(001) multilayer with gradually decreasing MgO layer thickness; (c) TEM electron diffraction pattern.

(describing growing its “Fe bottom electrode”). Iron (Fe), and also cobalt (Co), were well-known ferromagnetic materials. EX1030 ¶33 (“[F]erromagnetic materials” include “Fe, Co, Ni, and alloys containing them.”); EX1026 at 1655; EX1024 ¶250.

One of skill would have been motivated to replace Bowen’s first, Fe ferromagnetic material layer with a CoFeB ferromagnetic layer to increase TMR as taught by Wang. EX1055 at 2269-70 (“The benefit of using CoFeB is multifold: a higher TMR value” and explaining why a “high TMR value is desirable”); EX1024

¶¶253, 256.

One of skill would have looked to Wang's teachings to improve Bowen's MTJ because both Wang and Bowen focused on improving the TMR of MTJ devices, a problem to which the '138 Patent was directed. EX1011 at Abstract, 1:32-2:29; EX1024 ¶254. Like Wang, Bowen sought to increase the TMR in its MgO MTJ, EX1026 at 1655, 1657, and understood that the properties of the MTJ's electrodes contributed to improving the tunneling and hence TMR of its device, EX1026 at 1657; EX1024 ¶257. A skilled artisan knew that using CoFeB electrodes improved TMR and lowered H_f and H_c. EX1024 ¶256.

Wang and others recognized CoFeB was known to increase TMR compared to CoFe alloys. EX1055 at 2269-70 (changing NiFeCo to CoFeB increased TMR); EX1030 ¶¶24-29 (describing improvements to TMR by adding B to CoFe); EX1056 ¶¶39, 78, 103-04, Fig. 7; EX1061 at Abstract ("lower TMR" for "CoFe-based junctions" compared to CoFeB); EX1024 ¶¶255-58. CoFe was known to obtain better results than Fe. EX1035 at 3274; EX1024 ¶¶255-58. Other researchers obtained similar results. *E.g.*, EX1062 at 18:49-62 ("[V]ery high TMR values are unexpectedly found for MTJs with" CoFeB layers); EX1024 ¶256.

Wang studied the effect of using CoFeB for its MTJ ferromagnetic layers using aluminum oxide as the tunnel barrier. EX1055 at Abstract, 2269. Wang specifically found an initial increase in TMR from 43% to 61% when "changing the

free [ferromagnetic] layer from NiFeCo to CoFeB.” EX1055 at 2269. Wang concluded that “[w]ith such a large increase of TMR value by changing the free layer from NiFeCo to CoFeB, it is natural to replace both the free and pinned layers to CoFeB to further increase the TMR value.” EX1055 at 2270; EX1024 ¶¶255. Other researchers also recognized benefits in replacing both electrodes with CoFeB. EX1056 ¶¶67-68 (“[B]oth the ferromagnetic layers 5, 7 are made of an FeCoB” to achieve “improvement of the TMR ratio.”); EX1035 at 3274 (Fe and “CoFe alloys were tried in this study as both bottom and top electrodes.”); EX1061 at Abstract; EX1024 ¶¶256, 258.

Because Wang and others recognized that that CoFeB alloys had been successfully used as electrodes for MTJs, one of skill would have found it to be a straightforward, predictable, and desirable improvement to the TMR in Bowen’s MTJ. EX1055 at 2269-70; EX1030 ¶¶24-29; EX1056 ¶¶39, 78; EX1024 ¶¶256, 258; *KSR v. Teleflex*, 550 U.S. 398, 416 (2007) (“The combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results.”).

3. Claim 1[b]

Bowen disclosed or suggested an MgO(001) barrier layer: “We present tunneling experiments on Fe(001)/MgO(20 Å)/FeCo(001) single-crystal epitaxial junctions of high quality grown by sputtering and laser ablation.” EX1026 at

Abstract; *id.* at 1655 (describing an “Mg(001)” barrier where “the *MgO barrier* is grown at 400 °C in order to obtain good crystallinity.”), Fig. 1; EX1024 ¶¶259-66.

Bowen’s MgO barrier layer was disposed over the first electrode. Bowen describes its MTJ as an “Fe(001)/MgO(20 Å)/FeCo(001) single-crystal epitaxial junction[.]” EX1026 at Abstract; *see id.* at 1656 (describing “Fe(200 Å)/MgO(20 Å)/FeCo(250 Å) trilayer”). As shown at right, the MgO barrier is disposed over an “Fe bottom electrode.” EX1026 at 1655, Fig. 1 (annotated); EX1024 ¶260.

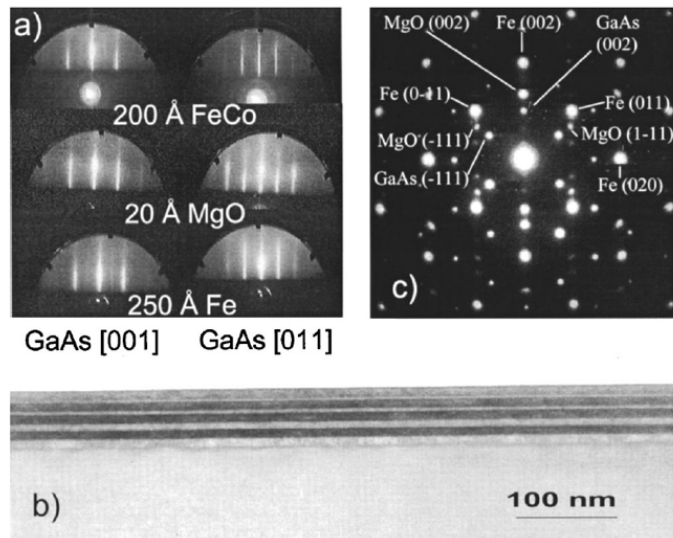


FIG. 1. (a) RHEED patterns along the GaAs [100] and [110] substrate azimuths of a typical FeCo/MgO/Fe epitaxial structure; (b) cross section TEM image of a Fe/MgO(001) multilayer with gradually decreasing MgO layer thickness; (c) TEM electron diffraction pattern.

As explained, disposing a barrier layer over the first electrode in an MTJ was conventional. *Supra* §VI.A.3, (Ground 1, Claim 1[b]); EX1024 ¶¶31-35, 261.

It would have been obvious to replace Bowen’s single-crystal MgO(001) barrier with polycrystalline MgO with the (001) crystal plane preferentially oriented. EX1024 ¶¶262-65. Bowen explained that Moodera’s 1996 study used “polycrystalline MgO” to obtain the same barrier height of 0.9 eV that Bowen obtained. EX1026 at 1656 (citing EX1038); EX1047 at 509, 511 nn. 5-7 (Moodera

1996 and other “[s]tudies using polycrystalline MgO indicated a low tunneling barrier of ≈ 0.9 eV (Refs. 5–7)”; *KSR*, 550 U.S. at 416 (“The combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results.”). IP Bridge apparently agrees. EX1008 at 289, 299-303 (Applicant acquiescing to Examiner rejection finding that Bowen “discloses a tunnel barrier layer comprises a poly-crystalline magnesium oxide layer in which a (001) crystal plane is preferentially oriented” in ’463 File History).

Like Bowen, one of skill would have understood that substituting polycrystalline MgO for single-crystal MgO would yield desirable and entirely predictable results, such as improved flexibility in substrate selection and improved manufacturability. EX1026 at 1656; EX1062 at 9:58-10:2 (describing use of polycrystalline or single-crystal MgO and explaining that polycrystalline structures are “preferable for ease of manufacturing”), 18:49-51 (“highly textured (100) MgO tunnel barriers”); EX1024 ¶¶262-65.

Further, using CoFeB electrodes as described in this Ground, one of skill would understand that Bowen’s MgO(001) barrier layer could be polycrystalline or single-crystal but would still maintain the same (001) orientation. EX1024 ¶266; EX1026 at 1655; EX1062 at 9:58-10:2 (describing use of polycrystalline or single-crystal MgO), 18:49-51 (“highly textured (100) MgO tunnel barriers”).

4. Claim 1[c]

This limitation was taught or suggested by Bowen in view of Wang. EX1024 ¶¶267-74. As explained, “second” refers to the “upper” ferromagnetic layer. *Supra* §VI.A.4 (Ground 1, Claim 1[c]); EX1024 ¶¶268-69. MTJs with ferromagnetic layers were conventional. *Supra* §VIII.A.2 (Ground 3, Claim 1[a]); EX1024 ¶¶54-62, 272.

As shown at right, Bowen taught a second, “top” FeCo ferromagnetic layer, instructing how to grow its “FeCo/MgO/Fe epitaxial structures” with the “FeCo top electrode.” EX1026 at 1655; *id.*

at Abstract, Fig. 1 (annotated), 1656; EX1024 ¶270. Bowen’s

upper FeCo electrode was grown on top of, or disposed over, the MgO barrier layer. EX1024 ¶270. Iron cobalt (FeCo) was a well-known ferromagnetic material. EX1030 ¶33; EX1024 ¶271.

As explained, one of skill would be motivated to substitute CoFeB for Bowen’s upper CoFe electrode as described in Wang with a reasonable expectation of success because CoFeB was known to improve TMR, and one of skill would have

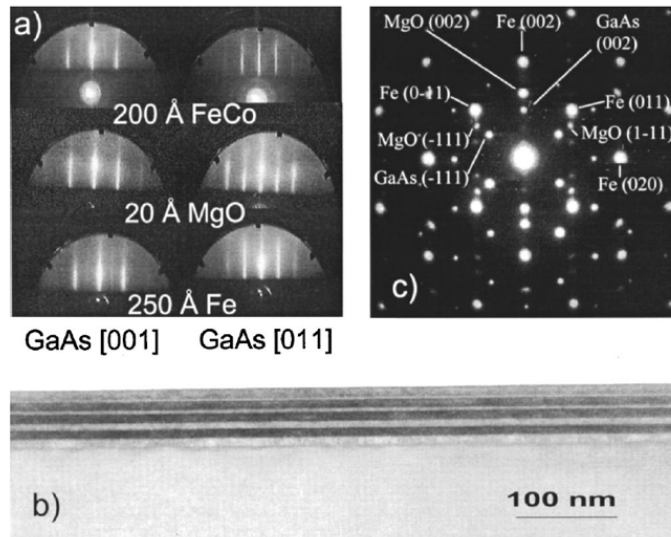


FIG. 1. (a) RHEED patterns along the GaAs [100] and [110] substrate azimuths of a typical FeCo/MgO/Fe epitaxial structure; (b) cross section TEM image of a Fe/MgO(001) multilayer with gradually decreasing MgO layer thickness; (c) TEM electron diffraction pattern.

been motivated to replace the upper electrode to further increase the TMR value. *Supra* §VIII.A.2 (Ground 3, Claim 1[a]); EX1024 ¶273. Wang and others recognized that CoFeB increased TMR compared to CoFe. EX1024 ¶¶256, 274.

5. Claim 1[d]

Claim 1[d] was taught or suggested by Bowen in view of Wang. EX1024 ¶¶275-84.

As discussed for Claims 1[a] and 1[c], one of skill would have replaced Bowen's Fe and FeCo electrodes with CoFeB layers. *Supra* §§VIII.A.2, VIII.A.4; EX1024 ¶276. Upon replacing those layers, the skilled artisan would have also recognized that annealing was necessary to produce optimum electrodes, which would have resulted in entirely crystallized CoFeB layers above and below the MgO tunnel barrier. EX1024 ¶¶277-80.

Both Bowen and Wang recognized that annealing produced better results. EX1026 at 1655 ("This low-temperature deposition and subsequent annealing process leads to an optimal Fe electrode in terms of crystallinity, continuity, and interface sharpness."); EX1055 at Abstract ("The tunnel junctions were annealed at 250 °C for 1 h and tested for magneto-transport properties with tunnel magnetoresistive (TMR) values as high as 70.4% at room temperature, which is the highest value ever reported for such a sandwich structure."). Thus, a skilled artisan

employing CoFeB layers would have annealed them with the expectation of higher TMRs. EX1024 ¶278.

Moreover, annealing MTJs including CoFeB layers was routine with a known expectation that it would be successful. EX1062 at 18:45-48 (“TMR values of more than 220% were found after an anneal treatment at 350 °C. The TMR of these devices was found to increase substantially on annealing as shown in FIG. 5.”); EX1061 at 2272 (“After deposition [including CoFeB], the structures were annealed 10 min at 280 °C....”), 2273; EX1056 ¶74 (“The ferromagnetic layer [of FeCoB or

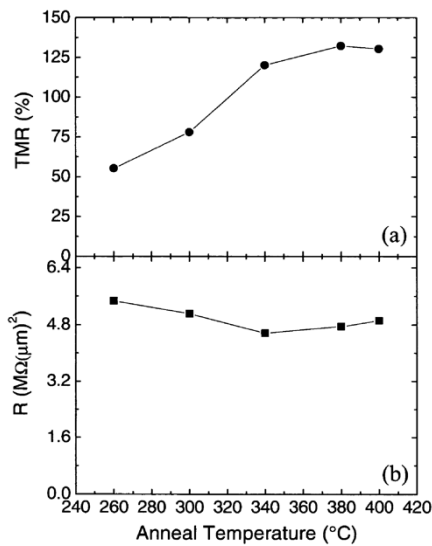


FIG. 5

FeCoNiB] is subjected to treatment of annealing within a magnetic field to completely impart magnetic anisotropy into the ferromagnetic layer.”); EX1024 ¶¶278-79, 282. Figure 5 at left shows the TMR of Parkin’s Figure 3A embodiment versus anneal temperature. EX1062 at 18:13-16, Fig. 5; EX1024 ¶283. A skilled artisan recognized that annealing was

important to increase TMR with CoFeB electrodes and thus would have employed annealing after replacing Bowen’s Fe and FeCo layers with CoFeB layers, as was routinely practiced in the field. EX1024 ¶¶278-79.

It was known that CoFeB layers crystallize at least partially upon annealing. *E.g.*, EX1061 at 2273 (“X-ray measurements of bulk CoFe and CoFeB 200 Å thick films (Fig. 3) confirmed that the CoFeB films are not amorphous.”). Parkin observed that “[c]ross-section transmission electron microscopy reveals that a portion of the [CoFeB] storage layer 175 *adjacent to the MgO tunnel barrier* 120’ has crystallized and is, moreover, textured in the same orientation as the crystalline MgO tunnel barrier.” EX1062 at 18:51-55. Thus, a skilled artisan understood that annealing CoFeB layers would result in crystallization of at least a portion of the CoFeB layers adjacent to the MgO tunnel barrier. EX1024 ¶¶279-80. Even if one of skill had not understood that crystallization occurred, crystallization was inherent in annealing. EX1024 ¶280.

As explained in Ground 1, the crystallized portion of the CoFeB layers adjacent to the MgO tunnel barrier would be an “entirely crystallized” layer, satisfying Claim 1[d]. *Supra* §VI.A.5; EX1062 at 19:17-27 (describing formation of “a thin crystalline layer of CoFeB” that “is much lower in B content”); EX1061 at 2273 (describing “strong texture enhancement upon annealing... for CoFeB films”); EX1024 ¶280 (explaining that even if the B content is lower in the thin interface crystallized layer, it is an “entirely crystallized” layer of CoFeB).

As explained, the prior art contains at least as much detail and is of the same character as what IP Bridge accuses of infringement, and thus IP Bridge concedes

that Claim 1[d] is shown by Bowen in view of Wang as discussed above. *Supra* §VI.A.5 (Ground 1, Claim 1[d]); EX1024 ¶281.

6. Claim 1[e]

Bowen alone or in view of Soukup taught or suggested this limitation. EX1024 ¶¶285-91. Oxygen vacancy defects between 0.9 and 1 for an MgO barrier were known. *E.g.*, EX1037 at 3; EX1024 ¶286.

As explained, the claimed “MgO_x” where the value of x “is greater than 0 and less than 1” refers to oxygen vacancy defects in the MgO layer. *Supra* §VI.A.6 (Ground 1, Claim 1[e]). Bowen described a “single-crystal... MgO(001)” barrier layer with oxygen vacancy defects. EX1026 at 1655; EX1024 ¶¶287-88.

Bowen observed a lower MgO tunnel “barrier height at $\phi = 0.9$ eV,” and attributed it to oxygen vacancy defects (stoichiometric inhomogeneities) in the MgO barrier:

This value is lower than half of the 5.5 eV MgO band gap calculated for an ultrathin layer. This difference may be due to metal-induced gap states in the MgO barrier although we cannot completely rule out the *presence of stoichiometric and/or thickness inhomogeneities in the insulating film.*

EX1026 at 1656; EX1024 ¶289.

Alternatively, Bowen in view of Soukup also taught or suggested an MgO barrier layer with oxygen vacancy defects. Soukup studied “the effect of

nonstoichiometry on the device characteristics,” EX1028 at 3232, and experimented with devices fabricated with different levels of nonstoichiometry, EX1028 at Abstract, 3232-33, Table I; EX1024 ¶¶290. One of skill would have understood that Bowen’s and/or Soukup’s stoichiometric inhomogeneities in the MgO barrier referred to oxygen vacancy defects in the MgO crystals. EX1011 at 6:32-34, 7:6-14; EX1042 at 162; EX1024 ¶¶73-82, 289-90.

One of skill 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 in Claim 4. *Infra* §VIII.D; EX1024 ¶¶291, 300-13.

B. Claim 2

Claim 2 was obvious for the reasons explained for Claim 1. *Supra* §VIII.A; EX1024 ¶¶292-96. As explained, Bowen in view of Wang and optionally Soukup suggest forming first and second ferromagnetic layers on both sides of and directly contacting the MgO barrier layer. *Supra* §§VIII.A.2-VIII.A.4 (Ground 3, Claims 1[a]-1[c]); EX1024 ¶¶295. As explained, MTJs with first and second ferromagnetic layers both directly contacting an MgO barrier layer were conventional. *Supra* §VI.B (Ground 1, Claim 2); EX1024 ¶¶54-62, 296.

Bowen taught the barrier layer directly contacted the lower, first ferromagnetic layer: “the **MgO barrier** is grown at 400 °C in order to obtain good

crystallinity” over the “Fe bottom electrode.” EX1026 at Abstract, 1655-56, Fig. 1; EX1024 ¶293; *supra* §VIII.A.3 (Ground 3, Claim 1[b]).

Bowen taught the upper, second ferromagnetic layer was grown on top of the MgO barrier. EX1026 at Abstract, 1655-56, Fig. 1 (describing growing “FeCo/MgO/Fe epitaxial structures” with a “FeCo top electrode); EX1024 ¶294; *supra* §VIII.A.4 (Ground 3, Claim 1[c]).

As explained, one of skill would also have been motivated to replace Bowen’s bottom Fe and top FeCo layers with CoFeB layers as taught by Wang and to anneal the MTJ. EX1024 ¶295; *supra* §§VIII.A.2-VIII.A.5 (Ground 3, Claims 1[a]-1[d]). Upon annealing, the CoFeB will crystallize adjacent to the MgO tunnel barrier forming first and second CoFeB layers in direct contact with the MgO tunnel barrier, both of which are entirely crystallized. EX1024 ¶295; *supra* §VIII.A.5 (Ground 3, Claim 1[d]).

C. Claim 3

Claim 3 is obvious for the same reasons explained for Claim 2. *Supra* Claims 1 and 2, §§VIII.A-VIII.B; EX1024 ¶¶297-98.

D. Claim 4

Claim 4 was obvious. EX1024 ¶¶299-314; *supra* §VIII.A (Claim 1). Tunnel barrier height measures the difference between the Fermi level of the electrode and

the bottom of the conduction band of the barrier layer. EX1031 at Fig. 1; EX1024 ¶¶45-49, 300.

Bowen in view of Soukup taught or suggested a tunnel barrier height for an MgO barrier layer in the disclosed range of 0.2 to 0.5 eV. EX1024 ¶300. Bowen “place[d] the barrier height at $\phi = 0.9$ eV” for its MgO barrier device. EX1026 at 1656; EX1024 ¶301. Soukup observed a “barrier height” within the disclosed range of “*about 0.33 eV*” for its MgO barrier. EX1028 at Abstract; *id.* at 3231-32, Fig. 5, Table I; EX1024 ¶301.

As explained, Soukup taught that oxygen vacancy defects impacted the barrier height for MgO and that a higher level of oxygen vacancy defects lowered the barrier height. EX1028 at 3232; *supra* §VI.D (Ground 1, Claim 4); EX1024 ¶¶302, 308.

One of skill 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. EX1028 at Abstract, 3232, 3236; EX1024 ¶¶303-05. According to the equation for TMR, lowering the resistance for parallel electrons (R_p) compared to anti-parallel electrons (R_{ap}) would improve TMR. EX1035 at 3273; EX1027 ¶2; EX1044 at 1-9; EX1045 at 1; EX1011 at 4:64-5:3; EX1024 ¶303. TMR was an “important parameter” for improving MRAM performance. EX1055 at 2269; EX1049 at 185-88, 194; EX1044 at 1; EX1045 at 1; EX1046 at 1; EX1035 at 3273; EX1027 ¶2; EX1024 ¶¶303-04. Skilled artisans, including Bowen, had long been

interested in increasing TMR to enable better performing MRAM. EX1026 at Abstract, 1655 (Bowen: “experimental results showing large TMR values” for MgO MTJ); EX1055 at 2269, 2271; EX1024 ¶¶31-35, 304-05.

Butler and Mathon 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. EX1044 at 1; EX1046 at 1; EX1024 ¶304. One of skill in the art looking to increase TMR of an MgO barrier would have been motivated to explore lower barrier heights to facilitate tunneling of parallel electrons. EX1024 ¶305. Thus, one of skill 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.* Indeed, both Bowen and Soukup studied properties of MgO barriers and were focused on improving tunneling devices, the problem to which the ’138 Patent was directed. EX1026 at Abstract, 1655-57; EX1028 at 3229-30; EX1011 at Abstract, 1:32-2:29; EX1024 ¶305.

One of skill would have had a reasonable expectation of success in achieving a tunnel barrier height in the claimed range in Bowen’s MTJ. EX1024 ¶306. Soukup fabricated an MgO barrier that achieved a height of 0.33 eV, EX1028 at Abstract, and one of skill in the art would have been motivated to achieve Soukup’s barrier height in an MgO MTJ to improve tunneling and hence TMR, EX1028 at Abstract,

3232, 3236; EX1024 ¶¶306, 308. One of skill would have predictably followed the trail blazed by Bowen and Soukup. EX1024 ¶¶307-313.

As explained, the claimed tunnel barrier height range of 0.2 to 0.5 eV also would have been obvious, and IP Bridge is no longer defending the patentability of this limitation and instead abandoning its remaining applications. *Supra* §§II.D, VI.D (Ground 1, Claim 4); EX1024 ¶309.

E. Claim 5

1. Claim 5[preamble]

Supra Claims 1[preamble] and 4, §§VIII.A.1, VIII.D; EX1024 ¶315.

2. Claim 5[a]

For all the reasons provided in Ground 2 for Claim 5[a], Bowen and Soukup taught using Simmons' formula to approximate tunnel barrier height. *Supra* §VII.A.2; EX1024 ¶¶316-17. Thus, one of skill would have found it obvious over Bowen in view of Soukup to use Simmons' formula to calculate the "barrier height ϕ ." *Id.*

3. Claim 5[b]

As explained in Ground 2, Claim 5[b] specifies the Simmons' formula variables, and some values of those variables, all of which was disclosed or suggested by Bowen and Soukup. *Supra* §VII.A.3 (Ground 2, Claim 5[b]); EX1024 ¶¶318-19.

F. Claim 6

Claim 6 was obvious. EX1024 ¶¶320-41; *supra* §VIII.A (Claim 1). Oxygen vacancy defects between 0.9 and 1 for an MgO barrier were known. *E.g.*, EX1037 at 3; EX1024 ¶321.

Additionally, the claimed “value of x in MgO_x” “greater than 0.9 and less than 1” was a result-effective variable within a skilled artisan’s grasp and achievable through routine optimization for all the reasons previously explained. *Supra* §VII.B (Ground 2, Claim 6); EX1024 ¶327. By the ’138 Patent’s priority date, skilled artisans, including Bowen, were already interested in increasing TMR to enable better performing MRAM, as explained for Claims 1[e] and 4. EX1026 at Abstract, 1655 (Bowen: “experimental results showing large TMR values” for MgO MTJ); EX1044 at 1; EX1045 at 1; EX1046 at 1; EX1055 at 2269, 2271; EX1024 ¶¶323-27; *supra* §§VIII.A.6, VIII.D. As discussed, Bowen attributed the lower observed MgO barrier height to oxygen vacancy defects. EX1026 at 1656; EX1028 at 3229-30; EX1024 ¶327; *supra* §§VIII.A.6, VIII.D (Ground 3, Claims 1[e]/4). Bowen’s and Soukup’s own MgO layer fabrication methods were taught by the ’138 Patent and comprised the generally acceptable conditions, and the claimed oxygen vacancy defects were a result-effective variable achievable by routine optimization. EX1024 ¶¶328-41; *supra* §VII.B (Ground 2, Claim 6).

G. Claim 7

1. Claim 7[preamble]

Supra Claim 1[preamble], §VIII.A.1; *see also infra* Claims 7[a]-7[f], §§VIII.G.2-VIII.G.7; EX1024 ¶342.

2. Claim 7[a]

Supra Claim 1[a], §VIII.A.2; EX1024 ¶343.

3. Claim 7[b]

Supra Claim 1[b], §VIII.A.3; EX1024 ¶344.

4. Claim 7[c]

Supra Claims 1[c], 7[a], §§VIII.A.4, VIII.G.2; EX1024 ¶345.

5. Claim 7[d]

As explained, Bowen's MgO barrier layer was located between its lower and upper electrodes. *Supra* Claims 1[a]-1[c], 2-3; §§VIII.A.2-VIII.A.4, VIII.B-VIII.C; EX1024 ¶¶346-47.

6. Claim 7[e]

Supra Claim 1[d], §VIII.A.5; EX1024 ¶348.

7. Claim 7[f]

Supra Claim 1[e], §VIII.A.6; EX1024 ¶349.

H. Claim 8

Supra Claims 2-3 and 7, §§VIII.B-VIII.C VIII.G; EX1024 ¶350.

I. Claim 9

Bowen in view of Wang and optionally Soukup teaches or suggests “first” and “second” interfaces between the MgO layer and two CoFeB electrodes. *Supra* Claims 2, 3 and 7, §§VIII.B-VIII.C, VIII.G; *supra* §VI.G (Ground 1, Claim 9); EX1024 ¶¶351-53.

J. Claim 10

Supra Claims 4 and 7, §§VIII.D, VIII.G; EX1024 ¶354.

K. Claim 11

1. Claim 11[preamble]

Supra Claims 1[preamble] and 10, §§VIII.A.1, VIII.J; EX1024 ¶355.

2. Claim 11[a]

Supra Claim 5[a], §VIII.E.2; EX1024 ¶356.

3. Claim 11[b]

Supra Claim 5[b], §VIII.E.3; EX1024 ¶357.

L. Claim 12

1. Claim 12[preamble]

Supra Claim 1[preamble], §VIII.A.1; *see also infra* Claims 12[a]-[d], §§VIII.L.2-VIII.L.5; EX1024 ¶358.

2. Claim 12[a]

Supra Claim 1[a], §VIII.A.2; EX1024 ¶359.

3. Claim 12[b]

Supra Claim 1[b], §VIII.A.3; EX1024 ¶360.

4. Claim 12[c]

Supra Claim 1[c], §VIII.A.4; EX1024 ¶361.

5. Claim 12[d]

Supra Claims 1[d]-1[e], §§VIII.A.5-VIII.A.6; EX1024 ¶362.

M. Claim 13

Supra Claims 4 and 12, §§VIII.D, VIII.L; EX1024 ¶363.

N. Claim 14

1. Claim 14[preamble]

Supra Claims 1[preamble] and 13, §§VIII.A.1, VIII.M; EX1024 ¶364.

2. Claim 14[a]

Supra Claim 5[a], §VIII.E.2; EX1024 ¶365.

3. Claim 14[b]

Supra Claim 5[b], §VIII.E.3; *see also supra* Ground 2, Claim 14[b], §VII.D.3; EX1024 ¶¶366-67.

IX. SECONDARY CONSIDERATIONS

Western Digital is unaware of any relevant secondary considerations of non-obviousness for the '138 Patent. EX1024 ¶368.

X. DISCRETIONARY DENIAL IS UNWARRANTED HERE

Discretionary denial under either Section 314(a) or 325(d) is inappropriate.

A. *Fintiv* Is No Roadblock To Institution

The *Fintiv* factors do not support denying institution under Section 314(a) here. *See Apple v. Fintiv*, IPR2020-00019, 2020 WL 2126495, at *2 (P.T.A.B. Mar. 20, 2020) (precedential).

IP Bridge stipulated to a stay pending IPR. EX1085. IP Bridge filed its initial complaint in March 2024 in the District of Delaware, EX1063, which transferred the case to the Northern District of California in September 2024, EX1080. The case remained in the pleading stage when stayed. *See* EX1077. Even if the stay lifts, there is no trial date and the 48.9-month median time to trial in the Northern District of California puts any trial long after the final written decision here. *F5 v. Sunstone Info.*, IPR2022-00483, Paper 13 at 12 (P.T.A.B. Aug. 12, 2022); EX1078 at 3.

To date, IP Bridge has asserted only a single claim of the '138 Patent in the litigation, EX1067 ¶144, while this Petition challenges all claims, leading to little risk of duplication, *see Precision Planting v. Maschio Gaspardo*, IPR2024-00008, 2024 WL 1283507, at *7 (P.T.A.B. Mar. 26, 2024). *Fintiv* presents no bar to instituting trial here.

B. Discretionary Denial Under 35 U.S.C. § 325(d) Is Unwarranted

Section 325(d) does not support discretionary denial. During prosecution of the '138 Patent, the examiner believed a critical limitation distinguishing the prior art was MgO with a barrier height in the range of 0.2 to 0.5 eV. EX1012 at 312. The

Examiner’s recent reversal and recognition that limitation was taught by the prior art shows that another look at these claims is warranted. *Supra* §II.D. Nor did the Examiner consider the combinations presented in this Petition. *See* EX1012 at 116-119, 197-203, 306-313. The Board has ample reason to conclude that *Advanced Bionics* does not apply.

The Board applies a two-part framework to determine whether Section 325(d) bars institution: (1) “whether the same or substantially the same art previously was presented to the Office,” and (2) “whether the petitioner has demonstrated that the Office erred in a manner material to the patentability of challenged claims.” *Advanced Bionics v. MED-EL Elektromedizinische Geräte*, IPR2019-01469, 2020 WL 740292, at *3 (P.T.A.B. Feb. 13, 2020) (precedential).

Advanced Bionics part 1 supports ordering trial here. The Board considers “the similarities and material differences between the asserted art and the prior art involved during examination, the cumulative nature of the art, and the overlap of the arguments presented.” *BMW of N. Am. v. Stragent*, IPR2021-00419, 2021 WL 3039219, at *5 (P.T.A.B. July 19, 2021) (citing *Advanced Bionics*, 2020 WL 740292, at *4).

During the initial examination in 2018, the Examiner stated his belief that “the prior art of record does not teach or suggest” a “barrier layer” with a barrier height “in a range of 0.2 to 0.5 eV.” EX1012 at 312. In 2024, the same Examiner changed

course, finding this limitation was not inventive because the prior art “Kishi teaches a barrier height of (0.1 eV to 0.85 eV) and (.2eV to .5eV).” EX1086 at 257; EX1087 at 200; *supra* §II.D. This misunderstanding alone warrants another look here. The Examiner was never presented with the Soukup reference, disclosing a barrier height of 0.33 eV in the claimed range. EX1028 at Abstract.

The Examiner also believed that “the prior art of record does not teach” a “value of x in MgO_x ” that “is greater than 0 and less than 1.” EX1012 at 312. But the Examiner apparently did not consider Bowen cited in a lengthy IDS, EX1012 at 187 (entry 3), because Bowen taught or suggested a MgO_x tunnel barrier layer where $0 < x < 1$. EX1026 at 1656; EX1024 ¶286. Wang was also disclosed in the same lengthy IDS, EX1012 at 189 (entry 11), but apparently never considered or used to reject claims.

The Examiner rejected claims over Parkin-852 (EX1090). EX1012 at 199. Parkin-852 is different from the Parkin presented in the Petition’s Grounds. Applicant argued that Parkin-852 taught “CoFe or CoFe/Fe layers,” not CoFeB layers that are “entirely crystallized” as required by the claims. EX1012 at 293-94. As shown, Parkin teaches this. *Supra* §§VI-VII. The Examiner later cited to Parkin’s published application (US 2006/0003185) to reject claims in one office action but solely relied on Parkin’s teachings of “BCC” structured “ferromagnetic material layers.” EX1012 at 308-09. The Examiner apparently did not recognize at

the time that Parkin further taught an MTJ with an MgO barrier and CoFeB electrodes, satisfying nearly every other aspect of the claims. *Supra* §§VI-VII; EX1062 at 18:63-19:10, 19:16, Fig. 3A; *Ceva Santé Animale v. Targan*, IPR2024-00595, 2024 WL 3656824, at *1, *6 (P.T.A.B. Aug. 5, 2024) (ordering trial because the examiner erred by citing prior art for one limitation and not “meaningfully consider[ing]” its entire disclosure).

Because this Petition presents new information that the Examiner did not have the opportunity to consider initially, its grounds were not “previously presented” to the Patent Office. *See, e.g., JUUL Labs. v. NJOY*, IPR2024-00160, 2024 WL 2697567, at *5 (P.T.A.B. May 24, 2024) (*Advanced Bionics* part one not met because “mere prior citation of prior art in an IDS will not automatically satisfy the first prong”).

If the Board deems consideration of step two necessary, it also supports instituting trial here. Material error by the Office “may include misapprehending or overlooking specific teachings of the relevant prior art where those teachings impact patentability of the challenged claims.” *Advanced Bionics*, 2020 WL 740292, at *3 n.9. As explained for step one, the Examiner was unaware in 2018 that the prior art taught or suggested MgO barrier heights in a range of 0.2 to 0.5 eV (Soukup and others), oxygen vacancy defects (Bowen), or that Parkin taught or suggested nearly every aspect of IP Bridge’s ’138 Patent claim iteration. *See* EX1012 at 312, 309.

Applicant never corrected the Examiner, and he issued the '138 claims. As a result, the Examiner erred in a way that was material to patentability.

Trial is warranted here.

XI. CONCLUSION

Western Digital respectfully requests judgment cancelling Claims 1-14 of U.S. Patent No. 10,367,138.

XII. GROUNDS FOR STANDING

Western Digital hereby certifies that the '138 Patent is available for IPR and meets the requirements of 37 C.F.R. §42.101.

XIII. MANDATORY NOTICES

Pursuant to 37 C.F.R. §42.8(a)(1), the mandatory notices identified in 37 C.F.R. §42.8(b) are provided below as part of this Petition.

A. Real Party-In-Interest (37 C.F.R. §42.8(b)(1))

Petitioner Western Digital Technologies, Inc., and related entity Western Digital Corporation, are the real parties-in-interest.

B. Related Matters (37 C.F.R. §42.8(b)(2))

Petitioner is currently aware of the following matters related to the '138 Patent: *Godo Kaisha IP Bridge 1 v. Western Digital Technologies, Inc.*, No. 24-cv-06555 (N.D. Cal.) (transferred from the District of Delaware); *Godo Kaisha IP*

Bridge 1 v. Seagate Technology LLC, No. 24-cv-03691 (D. Minn.) (transferred from the District of Delaware).

C. Lead and Backup Counsel (37 C.F.R. §42.8(b)(3))

Petitioner provides the following designation of counsel:

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Pursuant to 37 C.F.R. §42.10(b), a Power of Attorney accompanies this Petition.

D. Service Information (37 C.F.R. §42.8(b)(4))

Service information for lead and backup counsel is above. Petitioner hereby consents to service by email at the following email address: ipr@armondwilson.com.

ARMOND WILSON LLP

Dated: March 6, 2025

By: /Michelle E. Armond/

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Attorneys for Western Digital Technologies, Inc.

CERTIFICATE OF COMPLIANCE

Pursuant to 37 C.F.R. § 42.24(d), the undersigned certifies that foregoing
PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 10,367,138
exclusive of the parts exempted as provided in 37 C.F.R. § 42.24, contains 13,970
words and therefore complies with the type-volume limitations of 37 C.F.R. § 42.24.

ARMOND WILSON LLP

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CERTIFICATE OF SERVICE

I hereby certify that a true and correct copy of the foregoing **PETITION FOR
INTER PARTES REVIEW OF U.S. PATENT NO. 10,367,138** and **EXHIBITS
1001-1083, 1085-1095**, are being served on March 6, 2025, via overnight mail on the patent owner at the correspondence address of record for U.S. Patent No. 10,367,138, as addressed below:

Stites & Harbison PLLC
1800 Diagonal Road, Ste. 325
Alexandria, VA

A courtesy copy is also being served by electronic mail on counsel for the patent holder in the pending litigation:

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