Filed on behalf of Western Digital Technologies, Inc.
By: Michelle E. Armond
Douglas R. Wilson
Josepher Li
Monica Arnold
Yue Han
ARMOND WILSON LLP
4685 MacArthur Court, Suite 390
Newport Beach, CA 92660
Telephone: (949) 932-0778
Email: ipr@armondwilson.com

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. IPR2024-01494
U.S. Patent No. 11,968,909

PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 11,968,909

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1020	Japanese Patent No. JP2004071186
1021	English Translation of Japanese Patent No. JP2004071186, from '372 Patent File History (EX1016)
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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, *Godo Kaisha IP Bridge 1 v. Western Digital Corporation*, Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024) (without exhibits)
1064	Claim Chart for '403 Patent, Exhibit D to Complaint, *Godo Kaisha IP Bridge 1 v. Western Digital Corporation*, 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, *Godo Kaisha IP Bridge 1 v. Western Digital Corporation*, Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024)
1066	Claim Chart for ’372 Patent, Exhibit F to Complaint, *Godo Kaisha IP Bridge 1 v. Western Digital Corporation*, Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024)
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1068	Amended Claim Chart for ’403 Patent, Exhibit AA to First Amended Complaint, *Godo Kaisha IP Bridge 1 v. Western Digital Corporation*, Case No. 24-cv-00342-RGA (D. Del. July 8, 2024)
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1079	Microsoft Computer Dictionary (5th ed. 2002) (excerpts)
1080	Order Granting Motion to Transfer Venue to Northern District of California, *Godo Kaisha IP Bridge 1 v. Western Digital Corporation*, Case No. 24-cv-00342-RGA (D. Del. Sept. 4, 2024)
1081	U.S. Patent No. 7,751,156 (’156 Patent)
1082	U.S. Patent No. 8,427,791 (’791 Patent)
1083	U.S. Patent No. 8,914,970 (’970 Patent)

LIST OF CHALLENGED CLAIMS

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

> 1[a] first and second ferromagnetic material layer; and
>
> 1[b] a tunnel barrier layer between the first and second ferromagnetic material layers such that the tunnel barrier layer is above the first ferromagnetic material layer and below the second ferromagnetic material layer,
>
> 1[c] wherein said tunnel barrier layer comprises crystalline MgO_x (001) with oxygen vacancy defects and ($0<x<1$).

2. The magnetoresistive device of claim 1, wherein $0.9<x<1$.

3. The magnetoresistive device of claim 2, wherein $0.98<x<1$.

4. The magnetoresistive device of claim 3, wherein $0.99<x<1$.

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

6. The magnetoresistive device of claim 5, wherein the barrier height of the tunnel barrier layer is in a range of 0.2 eV to 0.5 eV.

7. The magnetoresistive device of claim 1, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer comprises Boron.

8. The magnetoresistive device of claim 1, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer is partially or entirely crystallized.

9[pre] A magnetoresistive device comprising a magnetic tunnel junction structure comprising:

> 9[a] first and second ferromagnetic material layer; and
>
> 9[b] a tunnel barrier layer between the first and second ferromagnetic material layers,

9[c] wherein said tunnel barrier layer comprises magnesium oxide and has a barrier height in a range of 0.1 eV to 0.85 eV.

10. The magnetoresistive device of claim 9, wherein the tunnel barrier layer comprises partially or fully crystalline magnesium oxide.

11. The magnetoresistive device of claim 10, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer is partially or entirely crystallized.

12. The magnetoresistive device of claim 11, wherein the barrier height is in a range of 0.2 eV to 0.5 eV.

13. The magnetoresistive device of claim 11, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer exhibits a body-centered cubic (BCC) structure.

14. The magnetoresistive device of claim 11, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer comprises Cobalt and Iron.

15[pre] A magnetoresistive device comprising:

15[a] a first ferromagnetic material layer;

15[b] a tunnel barrier comprising magnesium oxide and having a barrier height in a range of 0.2 eV to 0.5 eV; and

15[c] a second ferromagnetic material layer disposed on the tunnel barrier layer and separated from the first ferromagnetic material layer by the tunnel barrier layer.

16. The magnetoresistive device of claim 15, wherein the tunnel barrier layer comprises partially or fully crystalline magnesium oxide.

17. The magnetoresistive device of claim 16, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer is partially or entirely crystallized.

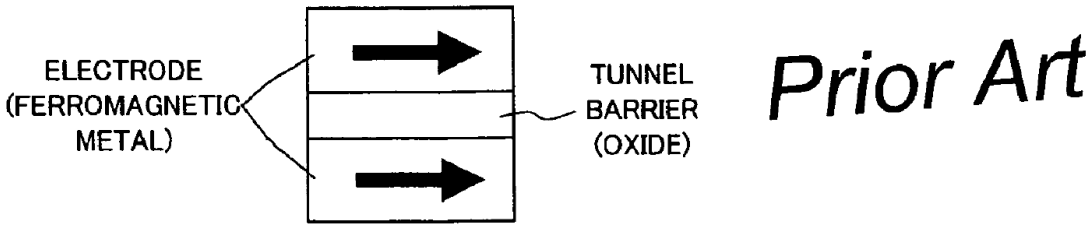
18. The magnetoresistive device of claim 17, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer exhibits a body-centered cubic (BCC) structure.

19. The magnetoresistive device of claim 17, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer comprises Cobalt and Iron.

20. The magnetoresistive device of claim 15, wherein the tunnel barrier layer has a thickness less than 10 nm.

I. INTRODUCTION

This IPR concerns the storage elements underlying magnetoresistive random-access memory (MRAM). MRAM is a niche memory device: a non-volatile random-access memory that stores data in magnetic storage elements called magnetic tunnel junctions (MTJs, shown below), comprising two ferromagnetic electrodes separated by a thin insulating layer:



Patent Owner IP Bridge claims Shinji Yuasa invented magnesium oxide MTJs used in MRAM as claimed in the '909 Patent at issue here and the related asserted patents. But "[n]onvolatile MRAM is not really new." EX1057 at xiv. Dr. Yuasa himself acknowledged that "[r]esearch and development of MRAM devices, which are fast and non-volatile memory devices, are being extensively carried out" before he filed his patent. EX1017 at 1:47-50. The '909 Patent instead purports to claim as its own decades of research by the brightest minds in quantum mechanics and device fabrication.

In the 1930s, researchers discovered a surprising phenomenon unexplained by classical physics: current flowing through a thin insulator sandwiched between two

electrodes. EX1031 at 1793 n.2. Simmons' influential 1963 paper quantified the "tunnel effect" and provided a formula for quantifying the "barrier height," or the energy required for electrons to tunnel across the insulating barrier. EX1031 at Abstract, 1797 (Eq. (25)).

During prosecution of the '909 Patent, the Examiner erroneously believed at applicant's urging that the claimed barrier height of 0.1–0.85 eV was inventive. EX1018 at 151, 164, 170. But the prior art, and Patent Owner's position that "the presence of oxygen vacancy defects indicates a tunnel barrier height as claimed" show otherwise. *E.g.*, EX1064 at 19 ('403 Patent infringement allegations); EX1028 at Abstract (Soukup: barrier height of 0.33 eV).

This Petition presents two grounds showing all claims of the '909 Patent were obvious:

- Bowen (Ground 1): Bowen observed the presence of defects in the MgO MTJ barrier led to increased tunneling, suggesting a low barrier height, previously observed by Soukup.
- Nagahama (Ground 2): Dr. Yuasa and collaborators (EX1027) disclosed nearly every aspect of an MgO MTJ he later sought to claim in the '909 Patent.

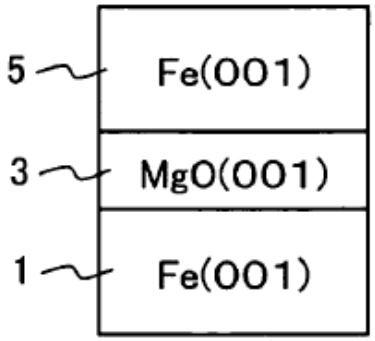
In short, Dr. Yuasa's effort to individually stake a claim to the territory of MgO MTJs should be rejected, and his claims revoked.

II. BACKGROUND

A. The District Court Litigation

A few years ago, Patent Owner IP Bridge bought Dr. Yuasa's patents on MgO-based MTJs, including the '909 Patent challenged here. EX1063 ¶¶3, 10; EX1067 (same). In March, IP Bridge filed suit against Western Digital, asserting that essentially its entire hard drive product line infringed three patents. EX1063 ¶¶28-30, 33-35. It filed a similar suit against Seagate. *Infra* §XII.B.

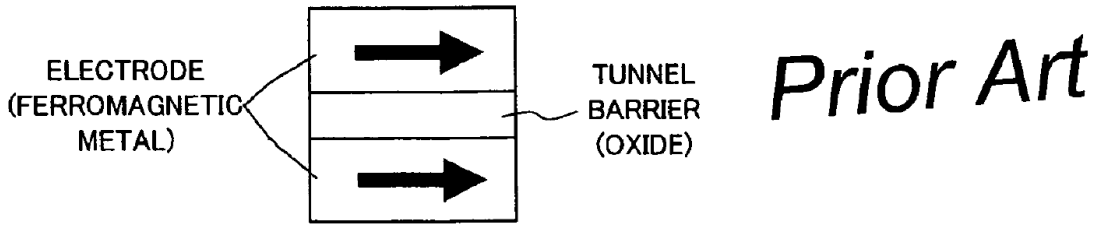
IP Bridge touted Dr. Yuasa's "pioneering contribution to the MgO-based MTJs" and explained that his patents "are directed to a MTJ structure comprising a thin insulating layer (a tunnel barrier layer) sandwiched between two ferromagnetic metal electrodes." EX1063 ¶¶12, 14. The Complaint says Dr. Yuasa's three-layer MTJ structure (right) obtained "the highest MR ratios." *Id.* ¶18.



Almost nothing has happened in the pending litigation. EX1077. Confronted with a motion to dismiss its original complaint, IP Bridge filed a First Amended Complaint asserting six more related patents, including the '909 Patent. EX1067 ¶2; EX1019. Western Digital filed another motion to dismiss (still pending) and requested transfer of the case from Delaware to the Northern District of California, which was granted on September 4, 2024. EX1080.

B. Magnetic Memory Development

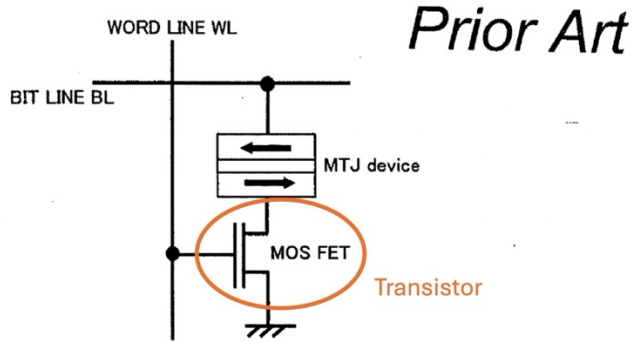
Conventional semiconductor-based memories like DRAM and EEPROM store data as electrical charges. EX1024 ¶30. Magnetic memory operates differently. As shown below, the simplest structure for magnetic memory conventionally is a magnetic tunnel junction (MTJ) with two ferromagnetic layers separated by a thin oxide layer:



EX1017 at Fig. 8(A); *see also id.* at Fig. 8(B), 1:51-2:9; EX1027 at Fig. 3; EX1030 at Fig. 1; EX1024 ¶¶31-35.

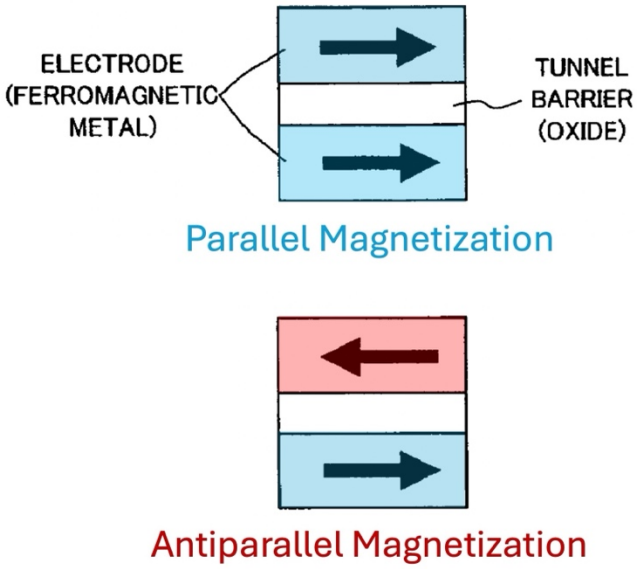
MRAM stores bits in MTJs, with a transistor typically controlling access to individual MTJs, as shown below.

FIG. 9 (B)



EX1017 at Fig. 9(B) (annotated); EX1030 ¶¶37-40, Figs. 4-5; EX1039 at 2816, 2818; EX1049 at Abstract, Fig. 2; EX1024 ¶30.

One MTJ electrode has a fixed polarity, while the other electrode's magnetization can be changed by an external electric field. EX1030 ¶19. To read the bit, typically the MRAM runs a small current through the electrodes and tunnel barrier and reads the resistance of the MTJ. *Id.*; EX1017 at 1:60-2:9. As shown at right, if the MTJ has low resistance, this indicates the electrodes have **parallel magnetization**; high resistance indicates **antiparallel magnetization**. EX1017 at 1:60-2:4, Figs. 8(A)-8(B) (excerpted, annotated). EX1024 ¶35.



Researchers were particularly interested in optimizing MTJs to improve MRAM performance. EX1026 at 1655; EX1045 at 1; EX1024 ¶31. An "important parameter" was the **tunnel magnetoresistance ratio (TMR)**, measuring the tunneling resistance across the MTJ. EX1055 at 2269. In 1973, the "pioneering work of Jullière" (EX1033), EX1057 at 9, discovered tunneling magnetoresistance in an MTJ at a low temperature (4.2 K, -452°F), EX1033 at 225. Mathematically,

TMR for an MTJ is equal to the difference in the resistance between the antiparallel (R_{ap}) and parallel states (R_p), divided by the parallel state resistance:

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

EX1035 at 3273; EX1027 ¶2; EX1017 at 5:8-16; EX1024 ¶37. Thus, high anti-parallel resistance R_{ap} compared to lower parallel resistance R_p results in high TMR. *Id.*

Higher TMRs long promised improved performance for MRAM. EX1049 at 186 ("[L]arger MR ratio is the [sic] another important issue for the high speed MRAM operations."); EX1017 at 2:49-67; EX1024 ¶¶36-44. High TMR allowed lower voltages (and smaller currents) to determine the MTJ's resistance (i.e., read the memory cell) and lowered power consumption. EX1055 at 2269; EX1024 ¶¶41-43. High TMR also improved the signal-to-noise ratio; made sensing the correct state more accurate; and paved the way for smaller, denser MRAMs. EX1055 at 2269; EX1049 at 194-95; EX1024 ¶¶41-44.

Two decades after Jullière, Miyazaki and Moodera separately measured TMR above 10%, demonstrating the tunneling effect at room temperature. EX1034 at Abstract. The patent acknowledges existing MTJ devices exhibited TMRs of "approximately 70%." EX1017 at 5:32-35; *see also* EX1057 at 43.

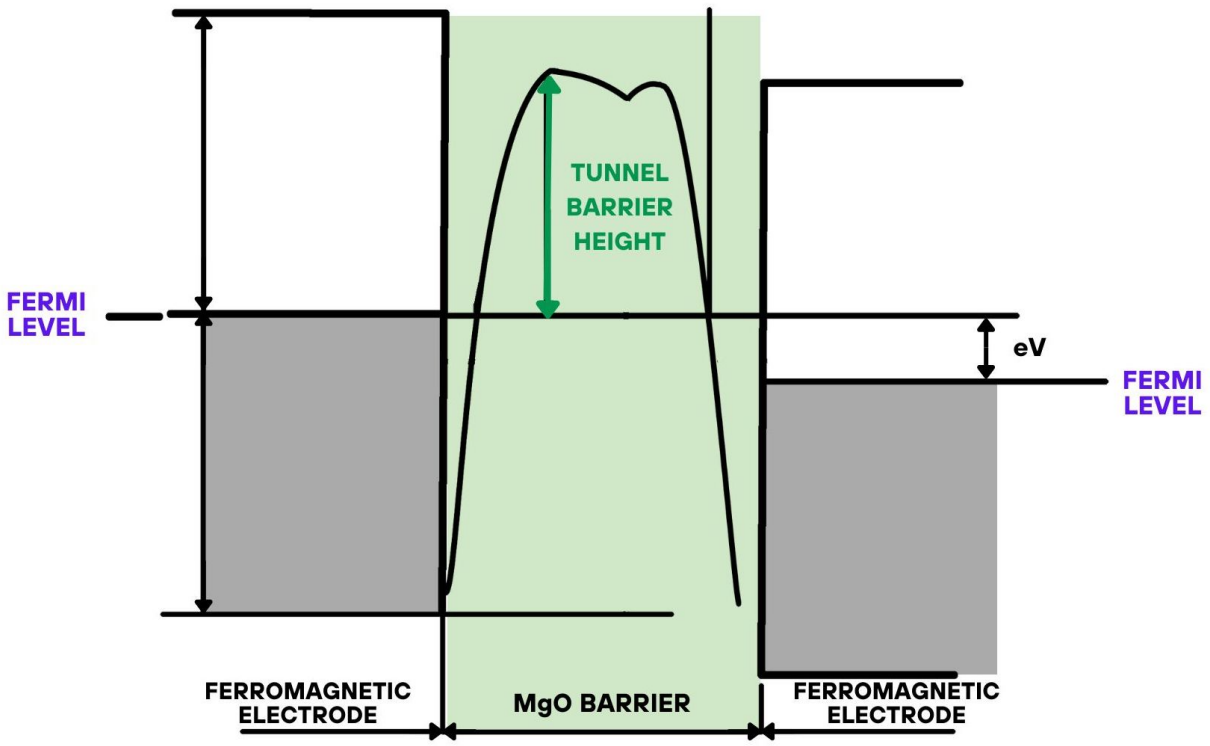
In 2001, Butler and Mathon separately calculated that MTJs with a crystalline MgO barrier layer would achieve TMRs of over 1000%. EX1053 at 8041, 8043 nn.9-10 (citing EX1044, EX1046). Their publications spurred a scientific gold rush, with researchers publishing an explosion of research into MgO MTJs. *See* EX1052 at 4507.

C. Quantum Tunneling In MTJs: Barrier Heights And Fermi Levels

MTJ behavior is explained by quantum mechanics. Current typically flows through conductors and is inhibited by insulators. EX1024 ¶¶45-49. But in the 1930s, researchers discovered that current (electrons) could flow between two electrodes separated by a very thin insulating layer (or barrier). EX1031 at 1793 n.2 (citing Sommerfeld and Bethe (1933)).

Simmons published an influential 1963 paper describing the "tunnel effect" of electrons across the barrier using quantum mechanics and providing a mathematical formula to estimate the barrier height, which is explained below. EX1031 at Abstract, 1797 (Eq. (25)).

The **Fermi level** (E_F) corresponds to this highest energy level occupied by electrons at 0 K. EX1024 ¶46. Electrons that lie close to the Fermi level participate in tunneling. *Id.*; EX1052 at 4508; EX1031 at 1802.



As shown above, tunneling can occur across a barrier (green) separating two ferromagnetic electrodes (gray). EX1031 at 1794, Fig. 1; EX1024 ¶46. At equilibrium, the Fermi levels (E_F) of the two electrodes align, so there is no net current flow (i.e., the same number of electrons tunnel in both directions across the barrier). EX1031 at 1796. If a bias voltage is applied to the junction, the Fermi level of the collector electrode (right) lowers by an amount (eV) compared to the injector electrode (left), allowing the electrons to tunnel across the barrier from the injector to empty states above the Fermi level in the collector. EX1031 at 1796, Figs. 1, 3.

In an MTJ, the **tunnel barrier height** represents the difference between the bottom of the conduction band of the tunnel barrier layer and the **Fermi level** of

electrons in the conductor. EX1031 at Fig. 1; EX1047 at 509; EX1017 at 4:2-8; EX1024 ¶48. Simmons' 1963 paper provided a widely used formula for calculating the tunnel barrier height.[1] EX1031 at 1797 (Eq. (25)); EX1026 at 1656; EX1035 at 3274; EX1017 at 7:39-45; EX1024 ¶49.

D. Research Into Materials To Increase TMR

It was known that "the tunnel characteristics are an intrinsic function of the thermal properties of the *insulator*, as well as of the electrodes." EX1031 at 1802 (emphasis in original); *see also* EX1050 at 2427. To improve tunneling and TMR, researchers studied different materials for the ferromagnetic electrodes and barrier layer. *E.g.*, EX1055 at 2269; EX1024 ¶¶50-72.

1. Ferromagnetic Materials

Well-known ferromagnetic materials such as Fe, Ni, Co, and their alloys typically have crystalline structures. EX1030 ¶33; EX1024 ¶54; *id.* ¶¶55-62. Alignment between the crystal of the electrodes and the barrier layer facilitates

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[1] Simmons' formula for the low-voltage range is:

$$J = [3(2m\varphi)^{\frac{1}{2}}/2s](e/h)^2 V \times \exp[-(4\pi s/h)(2m\varphi_0)^{\frac{1}{2}}].$$

EX1031 at 1797 (Eq. (25)). Researchers later corrected Simmons' formula to remove an erroneous factor of 3/2:

$$J_c = \frac{(2m\phi_0)^{\frac{1}{2}}}{s}\left(\frac{e}{h}\right)^2 V \exp\left[-\frac{4\pi s}{h}(2m\phi_0)^{\frac{1}{2}}\right].$$

EX1059 at 1 (Eq. (1)).

electron tunneling, reducing the barrier height and increasing TMR. EX1024 ¶56; EX1044 at 1; EX1046 at 1.

Researchers also found that alloys of iron (Fe) and cobalt (Co) improved TMR. EX1050 at 2428 (Yuasa 2002 study on FeCo electrodes); EX1026 at 1655 (depositing $Fe_{50}Co_{50}$ electrode layers); EX1052 at 4507 (using Fe and Co layers to try to achieve the calculated high TMRs); EX1024 ¶58.

By the early 2000s, researchers investigated using CoFeB alloys to increase TMR in magnetic memory. EX1030 ¶¶25-29; EX1055 at 2269-70 ("benefit of using CoFeB is multifold" including "a higher TMR value"); EX1056 ¶39. Introducing boron (B) to form a CoFeB electrode resulted in an initially "amorphous structure," EX1055 at Abstract, where "crystallization is inhibited," EX1030 ¶¶24-25, 30; EX1024 ¶¶59-61. As a result, a "CoFeB/MgO/CoFeB MTJ can theoretically be grown on all kinds of underlayers." EX1057 at 47. Without B, CoFe films had to be deposited as thicker or discontinuous films, decreasing TMR. EX1030 ¶27; EX1024 ¶¶60, 62.

2. Barrier Layers

Initially, there was significant interest in aluminum oxide (Al_2O_3) barrier layers. EX1024 ¶¶62-65; EX1052 at 4507; EX1044 at 1. But Al_2O_3 was amorphous and lacked an ordered crystalline lattice structure or symmetry with the electrodes. EX1044 at 1; EX1045 at 1; EX1017 at 5:39-47. This "lattice disorder" resulted in

incoherent tunneling with the electrons prone to scattering. EX1045 at 1. By the early 2000s, MTJs with Al_2O_3 barriers conventionally had TMRs "at approximately 70%." EX1017 at 2:61-63, 5:32-35; EX1063 ¶18; EX1055 at 2270 ("TMR value of 70.4%").

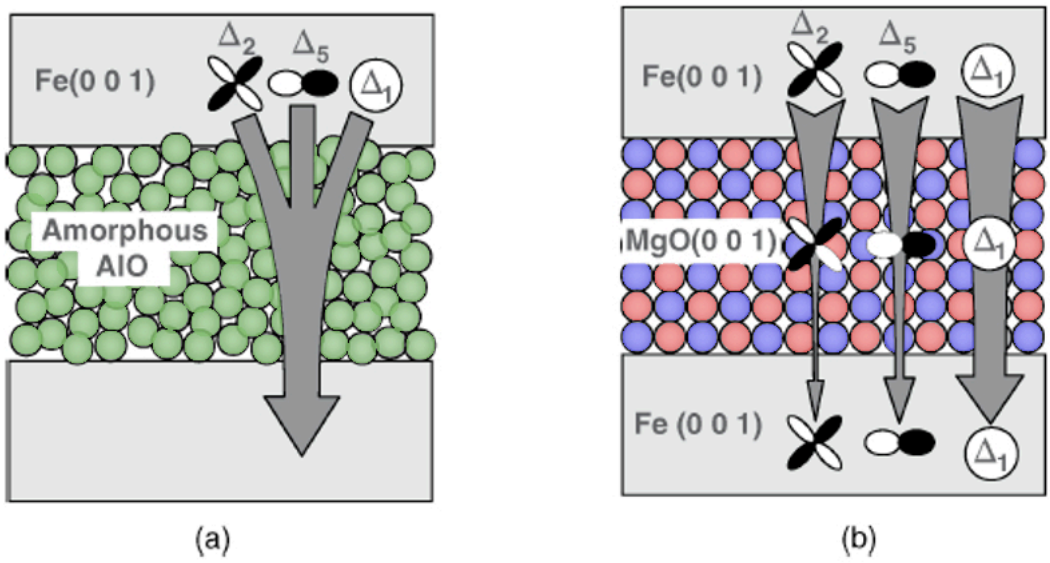
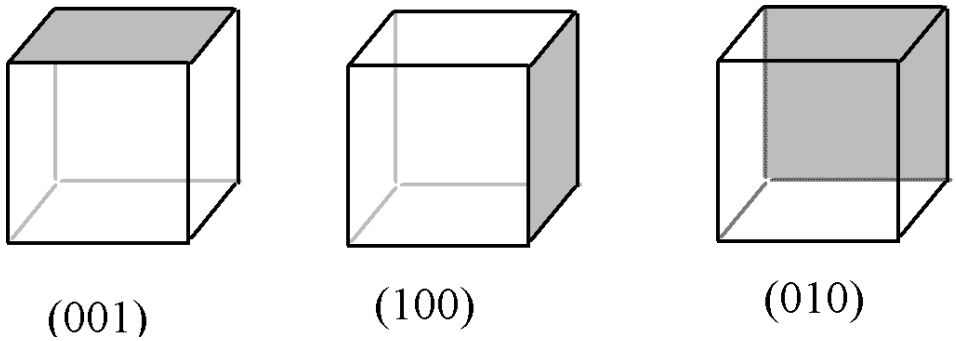


Figure 2.19 Schematic of electron tunneling through (a) an amorphous AlO barrier and (b) a crystalline MgO(0 0 1) barrier.

EX1057 at 44, Fig. 2.19 (annotated).

Thin-film magnesium oxide (MgO) barriers had been studied for years. EX1028 at 3229; EX1038 at Abstract; EX1024 ¶¶66-72. MgO was known to have a low barrier height because of its ordered crystalline structure. EX1028 at Abstract (0.33 eV barrier height of an MgO thin film); EX1024 ¶¶70-71.

Single-crystalline MgO barriers grew in a cubic crystalline lattice like table salt. EX1017 at 4:52-54; EX1040 at 2839. Its symmetric structure results in the (001), (100), and (010) crystalline planes being the same:



EX1017 at 4:52-54; EX1024 ¶¶66-67.

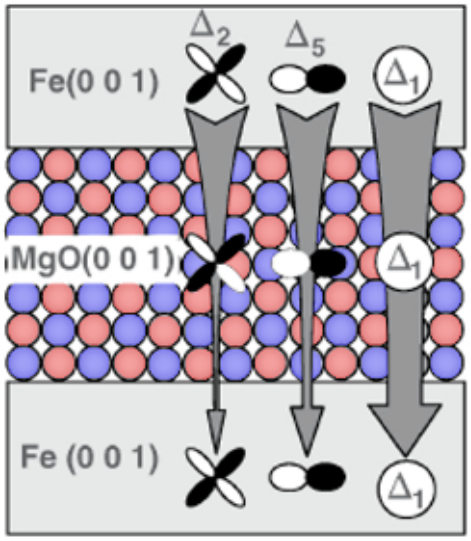
In 2001, Butler and Mathon separately "calculated [the] optimistic TMR ratio is in excess of 1000% for an MgO barrier." EX1046 at Abstract; *see also* EX1044 at Fig. 16; EX1024 ¶68. Butler pointed out that tunneling across an MgO barrier was facilitated by the "symmetry" between the electrodes and barrier material. EX1044 at 1; *see* EX1046 at 1. This symmetry permitted high TMRs because "[t]he tunneling resistance for the parallel" electrons was "estimated to be 100 times smaller than that for the antiparallel" electrons "due to the absence of scattering in the barrier." EX1045 at 1; *see also* EX1044 at 1; EX1024 ¶69.

Butler's and Mathon's breakthroughs generated considerable excitement for MgO thin-film MTJs. EX1053 at 8041, 8043 nn.9-10 (citing Butler and Mathon); EX1045 at 1, 8 n.3 (citing Butler); EX1024 ¶72.

E. Oxygen Vacancy Defects In MgO Thin Films

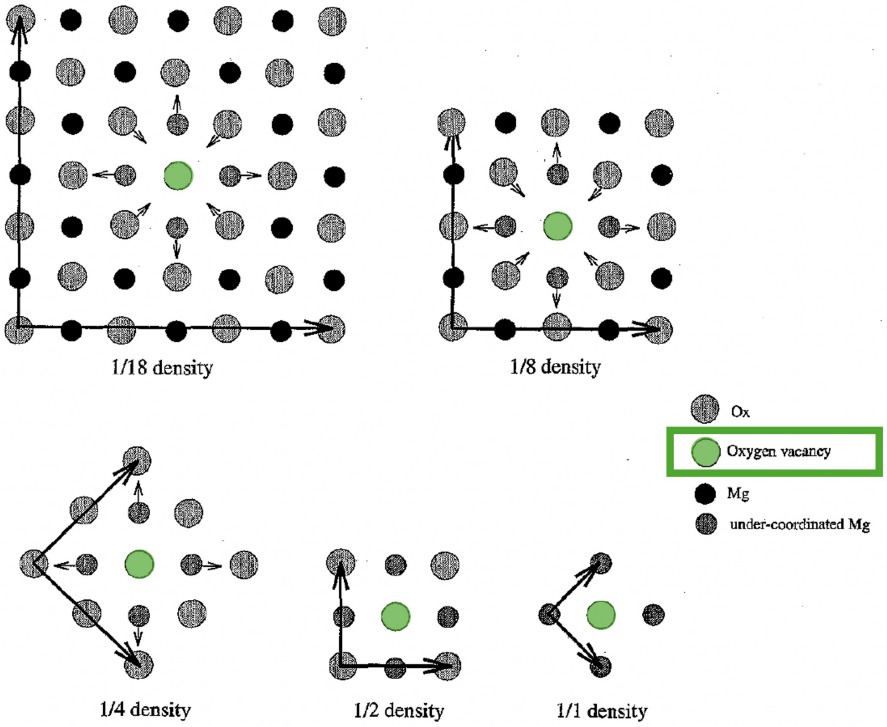
"One of the most important defects in oxides, if not the most important, is the oxygen vacancy." EX1042 at 162; *id*. at Abstract; EX1024 ¶¶73-82. "Oxygen vacancies are naturally present in every oxide…." EX1042 at 162; EX1008 ('463 File History) at 198.

The idealized MgO structure is stoichiometric with a 1:1 ratio of Mg (**blue**) and O atoms (**red**) in its cubic crystalline structure. EX1042 at 162; EX1017 at 6:44-46; EX1057 at 44, Fig. 2.19 (excerpted, annotated); EX1024 ¶¶63, 74. One way to quantify the level of oxygen vacancies in MgO crystal is by describing a sub-stoichiometric composition of MgO_x, where x<1 (x=1 in an idealized, perfectly stoichiometric crystal). EX1041 at 132 ("understoichiometric MgO_x (x < 1)"); EX1017 at 7:18-19, 7:34-36; EX1002 ('403 File History) at 168; EX1024 ¶¶74-75.



(b)

As shown below, oxygen vacancy defects (shown in **green**) result in a non-stochiometric MgO crystalline structure:



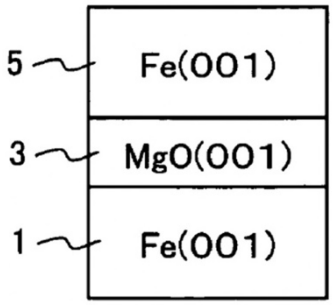
EX1037 at 3, Fig. 1 (annotated); *see also* EX1017 at 6:44-46; EX1024 ¶76.

Researchers understood that oxygen vacancy defects lowered the barrier height of the MgO thin film. Soukup experimentally observed a 0.33 eV barrier height of an MgO thin film, noting that increased oxygen vacancy defects lowered the barrier height of MgO. EX1028 at Abstract, 3232; EX1024 ¶77. Bowen also observed a lower barrier height of his MgO thin film and hypothesized that it may have resulted from "the presence of stoichiometric and/or thickness inhomogeneities in the insulating film." EX1026 at 1656; *see also* EX1062 at 17:37-39; EX1024 ¶82.

F. The '909 Patent

The '909 Patent teaches an MTJ with an MgO barrier layer sandwiched between two Fe electrodes. EX1017 at Fig. 1(B) (excerpted at right), 1:54-58, 5:51-57; EX1024 ¶¶83-86.

FIG. 1 (B)



G. The Prosecution Of The '909 Patent

The '909 Patent is in the same family as the '403 Patent and claims priority to JP 2004-071186 and 2004-313350. EX1017 at 1, [63], [30]. The '909 Patent is terminally disclaimed to the '403 Patent. EX1018 at 152-54.

The '909 Patent was allowed after a single office action where the examiner rejected pending claims as obvious over DeBrosse in view of Sharma. EX1018 at 107-09. In an interview and office action response, applicant argued that the prior art "fails to disclose a tunnel barrier made of MgO with a barrier height between .1eV to .85eV." *Id.* at 151, 162-64. The examiner agreed. *Id.* at 169-70.

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 review and cancellation of Claims 1-20 of the '909 Patent based on the following grounds.

Ground 1: Claims 1 and 8 are obvious over Bowen alone or in view of Soukup. Claims 2-6 and 9-20 are obvious over Bowen in view of Soukup. Claim 7 is obvious over Bowen in view of Sunai or Parkin and optionally Soukup.

Ground 2: Claims 1 and 8 are obvious over Nagahama alone or in view of Soukup. Claims 2-6 and 9-20 are obvious over Nagahama in view of Soukup. Claim 7 is obvious over Nagahama in view of Sunai or Parkin and optionally Soukup.

B. The Prior Art

1. March 10, 2004 Critical Date For The '909 Patent

The '909 Patent is a pre-AIA patent. Under pre-AIA §102(b), a person is not entitled to a patent if

> the invention was patented or described in a printed publication in this or a foreign country… more than one year prior to the date of the application for patent in the United States.

35 U.S.C. §102(b) (pre-AIA).

Under Section 102(b), the effective filing date is the international filing date, not the filing date of any foreign priority documents. *See, e.g.*, MPEP §2139.01.

"Under pre-AIA 35 U.S.C. 102(b), 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 '909 Patent claims priority to the '403 Patent PCT application, PCT/JP2005/04720 filed on March 10, 2005. EX1017 at 2, [63]; *see also id.* at 1:8-31. Because the international filing date of the '403 Patent is the March 10, 2005 PCT filing date, EX1001 at [22], the critical date for the '909 Patent is also March 10, 2004, *Group One v. Hallmark Cards*, 254 F.3d 1041, 1044-45 (Fed. Cir. 2001).

2. Prior Art Status

Bowen, Nagahama, Soukup, and Sunai are all prior art under at least pre-AIA 35 U.S.C. §102(a) and (b) because they were each published before the March 10, 2004 critical date for the '909 Patent:

- Bowen is a printed publication published on September 10, 2001. EX1026 at 1655.
- Nagahama is a European patent application published on February 25, 2004. EX1027 at [43].
- Soukup is a printed publication published on July 1, 1970. EX1028 at cover, 3229.
- Sunai is a Japanese patent application published on July 19, 2002. EX1030 at [43].

U.S. Patent No. 7,270,896 to Parkin was filed on July 2, 2004. EX1062 at [22]. Parkin is prior art under pre-AIA 35 U.S.C. §102(a) and (e) because it was filed before the earliest possible filing date and before the purported invention of the subject matter of the '909 Patent. Claim 7 of the '909 Patent requires that "the first ferromagnetic material layer and/or the second ferromagnetic material layer comprises Boron." EX1017 at 10:20-22. There is no disclosure of a ferromagnetic material layer that comprises Boron (*e.g.,* a CoFeB) in the March 12, 2004 Japanese application (JP 2004-071186) to which the '909 Patent claims priority. EX1017 at [30]. The earliest disclosure of a ferromagnetic material layer that comprises Boron, specifically, CoFeB, is the October 28, 2004 Japanese application (JP 2004-313350) to which the '909 Patent claims priority, rendering Parkin prior art under Section 102(a) and (e).

V. LEVEL OF ORDINARY SKILL IN THE ART

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

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

EX1024 ¶25. Less work experience may be compensated by a higher level of relevant education, and vice versa. *Id.* 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. EX1024 ¶¶24-29.

VI. GROUND 1: CLAIMS 1-20 ARE OBVIOUS OVER BOWEN (AND SUNAI OR PARKIN AND/OR SOUKUP)

A. Claim 1

Claim 1 would have been obvious over Bowen alone or in view of Soukup.

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

To the extent limiting, Bowen disclosed or suggested a magnetoresistive device with a tunnel barrier junction structure comprising a multi-layer material stack as claimed. *E.g.*, EX1026 at Abstract, 1655-56 (discussing FeCo/MgO/Fe epitaxial structure), Fig. 1; EX1024 ¶¶109-15; *see infra* §VI.A.

As the '909 Patent acknowledges, MTJs were well known. EX1017 at Figs. 8(A)-8(B), 1:51-2:9; EX1039 at 2816, Fig. 5 (describing a "[t]ypical MTJ material stack"); EX1071 at 3 (IP Bridge: "CoFeB/MgO/CoFeB-based stack" is "a stack that includes multiple materials and multiple layers, which is a multi-layer material stack"); EX1024 ¶¶112-15; *supra* §II.B.

2. Claim 1[a]: "first and second ferromagnetic material layer; and"

This limitation was taught or suggested by Bowen. EX1024 ¶116-23.

The "ferromagnetic material layer" refers to an "electrode made of a ferromagnetic metal." EX1017 at 1:54-57, Fig. 8(a); EX1024 ¶117; *supra* §II.B. As specified in Claim 1[b], "first" refers to the lower ferromagnetic electrode beneath the tunnel barrier layer that is closest to the substrate, and "second" refers to the "upper" ferromagnetic electrode above the tunnel barrier layer. EX1017 at 10:2-5; EX1024 ¶117.

Bowen disclosed:

- the "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 (describing growing its "Fe bottom electrode"); *id*. at Abstract, Fig. 1; EX1024 ¶118; and
- a second, "top" FeCo ferromagnetic material layer, instructing how to grow its "FeCo/MgO/Fe epitaxial structures" with the "FeCo top electrode." EX1026 at 1655; *id*. at Abstract, Fig. 1, 1657; EX1024 ¶119.

Both of these layers are shown in annotated Figure 1, below:

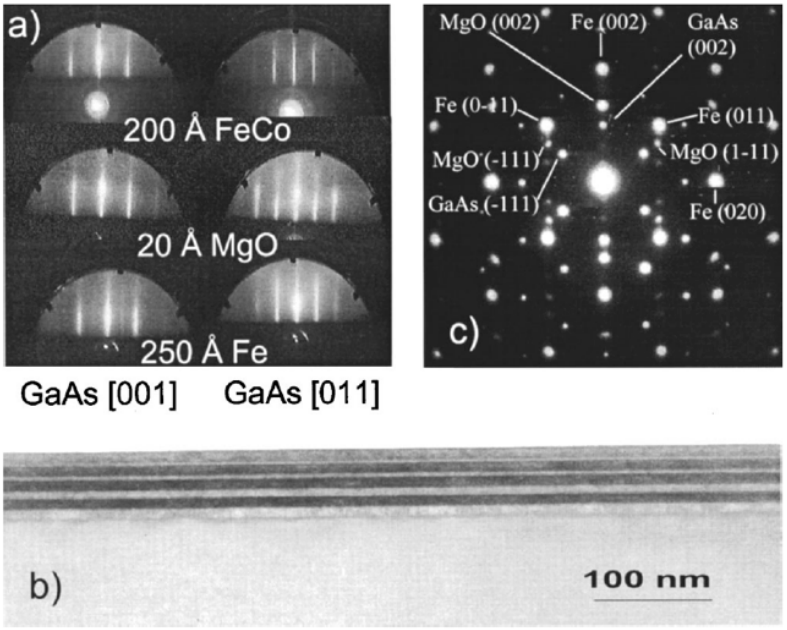


FIG. 1. (a) RHEED patterns along the GaAs [100] and [110] substrate azimuths of a typical FeCo/MgO/Fe epitaxial structure; (b) cross section TEM image of a Fe/MgO(001) multilayer with gradually decreasing MgO layer thickness; (c) TEM electron diffraction pattern.

EX1026 at Fig. 1 (annotated); EX1024 ¶120.

Iron (Fe) and iron cobalt (FeCo) were well-known ferromagnetic materials. EX1030 ¶33 ("[F]erromagnetic materials" include "Fe, Co, Ni, and alloys containing them."); EX1024 ¶¶121-22.

As the '909 Patent acknowledges, MTJs with two ferromagnetic layers were conventional. EX1017 at 1:54-57 (Description of Related Art); *id*. at Figs. 8(A)-8(B); EX1045 at 1 (describing "Fe/MgO/Fe(001) trilayers"); EX1024 ¶123; *supra* §II.D.1.

3. Claim 1[b]: "a tunnel barrier layer between the first and second ferromagnetic material layers such that the tunnel barrier layer is above the first ferromagnetic material layer and below the second ferromagnetic material layer,"

Bowen disclosed or suggested an MgO tunnel barrier layer as claimed. EX1024 ¶¶124-28. The "tunnel barrier" layer refers to "an oxide [that] is sandwiched between a first and a second electrode made of a ferromagnetic metal." EX1017 at 1:54-57; EX1024 ¶125. Bowen described "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 ("[T]he ***MgO barrier*** is grown at 400 °C in order to obtain good crystallinity."), Fig. 1; EX1024 ¶126.

Bowen's tunnel barrier layer was located above the first, and below the second, ferromagnetic material layers. 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"). The MgO barrier is located between a first "Fe bottom electrode" and a second "FeCo top electrode." EX1026 at 1655; EX1024 ¶127; *supra* §VI.A.2 (Claim 1[a]).

The '909 Patent acknowledges that a tunnel barrier layer placed between two ferromagnetic layers in an MTJ was conventional. EX1017 at 1:54-57 (Description

of Related Art); *id*. at Figs. 8(A)-8(B); EX1045 at 8 (describing "high quality… MgO tunnel barrier"); EX1024 ¶128; *supra* §II.B.

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

Bowen alone or in view of Soukup taught or suggested this limitation. EX1024 ¶¶129-36. As explained for Claim 1[b] in this Ground, Bowen disclosed a "single-crystal… MgO(001)" tunnel barrier layer. EX1026 at 1655; *id*. at Abstract ("We present tunneling experiments on Fe(001)/***MgO***(20 Å)/FeCo(001) ***single-crystal*** epitaxial junctions of high quality….")[2]; EX1024 ¶130; *supra* §VI.A.3.

Bowen taught or suggested single-crystalline MgO_x (001) where 0<x<1, a mathematical notation indicating less than a one-to-one stoichiometric ratio of oxygen to magnesium (i.e., oxygen vacancy defects) in the MgO layer. EX1026 at 1656; EX1024 ¶¶131-32; EX1017 at 6:44-46, 7:18-19; EX1002 ('403 File History) at 168 (Applicant: "MgO_x (0 < x < 1)" means the MgO "crystals 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."); *supra* §II.E. MgO with oxygen vacancy defects was inherently MgO_x where 0<x<1 because x has to be greater than 0 to constitute MgO and less than 1 to constitute

[2] All emphasis added unless otherwise noted.

nonstoichiometric MgO with oxygen vacancies. EX1024 ¶133; EX1008 at 198; EX1037 at 3. Bowen observed a lower MgO tunnel "barrier height at $\phi = 0.9$ eV," EX1026 at 1656, 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***.

Id.; EX1024 ¶134.

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 ¶135. 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 crystal. EX1017 at 6:44-46, 7:18-26; EX1042 at 162; EX1024 ¶¶134-35; *supra* §II.E.

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 5. *Infra* §VI.E; EX1024 ¶136; *id.* ¶¶166-79.

B. Claim 2: "The magnetoresistive device of claim 1, wherein 0.9<x<1."

Claim 2 would have been obvious over Bowen in view of Soukup. EX1024 ¶¶137-58; *supra* §VI.A (Claim 1). Oxygen vacancy defects between 0.9 and 1 for an MgO barrier were known. *E.g.*, EX1037 at 3; EX1024 ¶¶138-39.

Additionally, the claimed range "0.9<x<1" 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) ("[T]he Board's finding that the dimensional variables were result-effective, rendering their optimization within the grasp of one of ordinary skill in the art, was supported by substantial evidence."). Indeed, the Examiner recognized that it "would have been obvious to one having ordinary skill in the art at the time the invention [*sic*] was made to optimize the oxygen deficiency." EX1016 ('372 File History) at 91.

The '909 Patent disclosed that the claimed invention was directed to an MTJ device with a high TMR. EX1017 at 1:37-40; 3:1-4; 5:10-16 (disclosing the equation for determining the "magnetoresistance (MR) ratio of a MTJ device"); *supra* §II.F. By the '909 Patent's priority date, skilled artisans, including Bowen, were already interested in increasing TMR to enable better performing MRAM, as

explained for Claim 5. EX1026 at Abstract, 1655 (Bowen: "experimental results showing large TMR values" for MgO MTJ); EX1055 at 2271; EX1024 ¶¶140-43; *infra* §VI.E; *supra* §II.B. 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; EX1026 at Abstract, 1655-57; EX1028 at 3229-30; EX1024 ¶¶144, 154; *supra* §§II.D-II.E. 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 de Nemours & Co 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 Claims 1[c] and 5 of Ground 1, Bowen attributed the lower MgO barrier height observed to oxygen vacancy defects. EX1026 at 1656; EX1024 ¶¶134, 154; *supra* §VI.A.4; *infra* §VI.E. 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, EX1028 at Abstract, 3232-33, Table I; EX1024 ¶144. As explained in Claim 1[c], MgO with oxygen vacancy defects is inherently MgO_x where $0<x<1$. *Supra* §VI.A.4; EX1024 ¶¶131-33. Thus, MgO_x where $0.9<x<1$ is merely a subrange within that which is disclosed inherently by Bowen 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 '909 Patent disclosed two MTJ device embodiments. EX1024 ¶¶145-50. 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. EX1017 at 6:36-44, 6:50-54, 7:1-3; EX1024 ¶146. This first MTJ device embodiment reportedly yielded a TMR of about 88% at room temperature, EX1017 at 8:15-19, Fig. 6; EX1024 ¶147, wherein there was the "possibility" that the MgO layer had oxygen vacancy defects "such as MgO_x ($0.9<x<1$)," EX1017 at 7:18-19, Figs. 4-5; EX1024 ¶148.

The MgO layer of the second "Fe(001)/MgO(001)/Fe(001) MTJ device" in the '909 Patent was "deposited in a poly-crystalline or amorphous state by sputtering or the like." EX1017 at 8:53-58; EX1024 ¶149. 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." EX1017 at 8:64, 9:48-50; EX1024 ¶150. TMR and the quantity of the oxygen vacancy defects were not specifically disclosed. *See generally* EX1017.

Bowen's and Soukup's MgO layer fabrication methods comprised the general acceptable conditions, according to the '909 Patent's disclosure. *DuPont*, 904 F.3d at 1006; EX1024 ¶151. Indeed, the '909 Patent disclosed "it should be obvious that" either electron-beam evaporation or sputtering were possible MgO deposition methods, EX1017 at 9:45-48, indicating the deposition method was not inventive, EX1024 ¶151.

Bowen's MgO layer was deposited using sputtering like the '909 Patent's second MTJ device embodiment. EX1017 at 8:53-58; EX1026 at 1655; EX1024 ¶152. Specifically, Bowen grew its MgO(001) crystal "in a combined sputtering/laser ablation system with a base pressure of 2×10^{-9} mbar," or 2×10^{-7} Pa (or 0.2×10^{-6} Pa). EX1026 at 1655; EX1024 ¶152. Bowen did not expressly disclose whether its MgO layer was deposited in the presence of oxygen, but its disclosed vacuum pressure of 2×10^{-7} Pa (or "2×10^{-9} mbar") during deposition was within the limits disclosed by the '909 Patent. *See* EX1017 at 9:48-52 ("on the order of no more than 10^{-6} Pa" when oxygen was not introduced and "on the order of 10^{-4} Pa" when oxygen was introduced); EX1024 ¶152.

Soukup's MgO layer was deposited using electron beam evaporation like the '909 Patent's first MTJ device embodiment. EX1017 at 6:19-26, 6:50-54; EX1024 ¶153. Specifically, Soukup deposited its MgO layer using an "evaporation source" at 10^{-8} Torr," or 1.33×10^{-6} Pa, wherein the thickness of the film was determined by "precalibrating deposition rate vs electron beam power." EX1028 at 3230; EX1024 ¶153.

While Bowen and Soukup did not expressly quantify the oxygen vacancy defects in their respective MgO layers, as explained in Claim 1[c] of this Ground, one of skill understood that oxygen vacancy defects necessarily resulted in an MgO_x barrier layer with $0<x<1$, EX1024 ¶154; *supra* §II.E, that these defects impacted the barrier height, EX1028 at Abstract, 3232; EX1026 at 1656; EX1024 ¶154, and that reducing the barrier height was desirable for achieving higher TMR, EX1044 at 1; EX1046 at 1; EX1024 ¶¶154, 168-69. Oxygen vacancy defects are obvious as a result-effective parameter. *E.g.*, *Pfizer v. Sanofi Pasteur*, 94 F.4th 1341, 1348 (Fed. Cir. 2024) ("A routine optimization analysis generally requires consideration whether a person of ordinary skill in the art would have been motivated, with a reasonable expectation of success, to bridge any gaps in the prior art to arrive at a claimed invention. Where that gap includes a parameter not necessarily disclosed in the prior art, it is not improper to consider whether or not it would have been

recognized as result-effective. If so, then the optimization of that parameter is 'normally obvious.'" (citation omitted)).

Moreover, Soukup's barrier height of 0.33 eV was within the range disclosed by the '909 Patent as indicative of "oxygen vacancy defects." EX1028 at Abstract; EX1017 at 7:19-23; EX1024 ¶157. Thus, according to the '909 Patent, its claimed oxygen vacancy defect ranges are inherent in Soukup. *See Arbutus Biopharma.v. ModernaTX*, 65 F.4th 656, 662 (Fed. Cir. 2023) ("We have also explained that '[n]ewly discovered results of known processes directed to the same purpose are not patentable because such results are inherent.'" (quoting *Bristol-Myers Squibb Co. v. Ben Venue Labs., Inc*., 246 F.3d 1368, 1376 (Fed. Cir. 2001)).

Additionally, the '909 Patent did not disclose that the effect of oxygen vacancy defects generally, or specifically in the claimed range of "0.9<x<1," was somehow new or unexpected. *See* EX1017 at 7:8-38. The '909 Patent did not identify anything inventive about its MgO layer deposition methods, EX1017 at 9:45-48; EX1024 ¶155, and disclosed that obtaining oxygen vacancy defects could be introduced by a variety of standard methods, EX1017 at 9:4-11; EX1024 ¶155. None of these methods were identified as inventive or unexpectedly leading to higher-than-expected performance. *See* EX1017 at 9:4-11; *DuPont*, 904 F.3d at 1006.

Indeed, the '909 Patent's own disclosure indicates the "0.9<x<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)." EX1017 at 7:16-19; EX1024 ¶156. 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." EX1017 at 9:43-9:45; EX1024 ¶158.

Claim 2 was disclosed or suggested by Bowen and/or in view of Soukup and would have also been obvious because its "0.9<x<1" limitation is a result-effective variable that was not critical to the claimed invention and was achievable by a skilled artisan through routine optimization.

C. Claim 3: "The magnetoresistive device of claim 2, wherein 0.98<x<1."

This claim was disclosed or suggested by Bowen in view of Soukup. EX1024 ¶¶159-61; *supra* §§VI.A-VI.B (Claims 1-2).

As explained for Claim 2, this claim would have also been obvious because the claimed MgO_x oxygen vacancy defect range, "0.98<x<1," overlapped with the 0<x<1 range inherent in Bowen and Soukup; was a result-effective variable, which is not critical to the object of the invention; was within a skilled artisan's grasp; and was achievable through routine optimization. EX1024 ¶160; EX1016 at 91

(Examiner in '372 Patent: obvious "to optimize the oxygen deficiency"); *supra* §VI.B. Additionally, as explained in Claim 2 in this Ground, according to the '909 Patent, its claimed oxygen vacancy defect ranges are inherent in Soukup. *See Arbutus*, 65 F.4th at 662.

Similarly, the "0.98<x<1" range was also speculative. The only disclosure related to the concept of quantifying the oxygen vacancy defects in an MgO layer refers to the first MTJ device embodiment, EX1017 at 7:1-38, Figs. 4-5; EX1024 ¶161, wherein in reference to the method of the first MTJ device embodiment, the specification disclosed that the "value of x in MgO_x due to oxygen vacancy defects is such that ***0.98<x<1***, and more preferably 0.99<x<1." EX1017 at 7:28-30, 7:34-36; EX1024 ¶161. However, this "0.98<x<1" range was only more speculation based on the already speculative "(0.9<x<1)" range. *See* EX1017 at 7:34-36; EX1024 ¶161. Indeed, the specification also disclosed alternative MTJ fabrication methods for obtaining a lower barrier height unrelated to MgO oxygen vacancy defects, EX1017 at 9:42-45, indicating this oxygen vacancy range was not critical to the object of the invention, EX1024 ¶158; *supra* §VI.B.

D. Claim 4: "The magnetoresistive device of claim 3, wherein 0.99<x<1."

This claim was disclosed or suggested by Bowen in view of Soukup. EX1024 ¶¶162-64; *supra* §§VI.A-VI.C (Claims 1-3).

Additionally, this claimed MgO layer oxygen vacancy range was also obvious because it overlapped with the 0<x<1 range inherent in Bowen and Soukup and was a result-effective variable for the same reasons described in Claims 2-3. EX1024 ¶163; EX1016 at 91; *supra* §§VI.B-VI.C. Additionally, as explained for Claims 2-3, the claimed oxygen vacancy defect ranges are both inherent in Soukup and speculative. EX1024 ¶164; *supra* §§VI.B-VI.C.

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

This claim was taught or suggested by Bowen in view of Soukup. EX1024 ¶¶165-80; *supra* §VI.A (Claim 1). As explained, 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 ¶166; *supra* §II.C.

Bowen in view of Soukup taught or suggested a tunnel barrier height for an MgO barrier layer in the disclosed range of 0.1 to 0.85 eV. EX1024 ¶166. Bowen "place[d] the barrier height at ϕ = 0.9 eV" for its MgO barrier device. EX1026 at 1656; EX1024 ¶167. 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 ¶167.

Soukup taught that oxygen vacancy defects had an impact on the barrier height for MgO. EX1024 ¶168. 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 ¶168. 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 ¶168.

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 ¶¶169-71. According to the equation for TMR, lowering the resistance (barrier height) for parallel electrons (R_p) would improve TMR. EX1035 at 3273; EX1027 ¶2; EX1017 at 5:10-16; EX1024 ¶169. TMR was an "important parameter" for improving MRAM performance. EX1055 at 2269; EX1024 ¶170. 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 2271; EX1024 ¶170; *supra* §II.B.

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 ¶170. 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 ¶171. 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. EX1024 ¶171. Indeed, both Bowen and Soukup studied properties of MgO barriers and were focused on improving tunneling devices, the problem to which the '909 Patent was directed. EX1026 at Abstract, 1655-57; EX1028 at 3229-30; EX1017 at Abstract, 1:37-2:39; EX1024 ¶171.

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 ¶172. 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 ¶172. One of skill would have predictably followed the trail blazed by Bowen and Soukup. *Id*.

The claimed tunnel barrier height range of 0.1 to 0.85 eV also would have been obvious. EX1024 ¶173. The claimed range is only slightly below the barrier height at "0.9 eV" taught by Bowen and others. EX1026 at 1656 (citing EX1038); EX1038 at 4725-26; EX1024 ¶173. One of skill was aware that oxygen vacancy defects impacted the barrier height. Bowen itself hypothesized that the low barrier

height they observed, which was "lower than half" of the calculated value for "an ultrathin layer" of MgO, may be due to the "presence of stoichiometric… inhomogeneities in the insulating film." EX1026 at 1656; EX1024 ¶174. 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.

Further, the '909 Patent itself 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 0.10 to 0.85 eV…), which is thought to result in an increase in the tunneling current." EX1017 at 7:19-22. Thus, according to the '909 Patent, the tunnel barrier height limitation is inherent when there are oxygen vacancy defects as disclosed by both Bowen and Soukup. EX1026 at 1656; EX1028 at 3232, 3236; EX1024 ¶175. Additionally, in the co-pending litigation, IP Bridge asserted that the similar requirement "tunnel barrier height in a range of 0.2 to 0.5 eV" is satisfied by the mere "presence of oxygen vacancy defects." 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).

F. Claim 6: "The magnetoresistive device of claim 5, wherein the barrier height of the tunnel barrier layer is in a range of 0.2 eV to 0.5 eV."

This claim requiring an overlapping tunnel barrier height "in a range of 0.2 eV to 0.5 eV" was taught or suggested by Bowen in view of Soukup for the reasons provided in Claim 5. *Supra* §VI.E; EX1028 at Abstract (Soukup: MgO barrier height of "about 0.33 eV"); EX1024 ¶181.

G. Claim 7: "The magnetoresistive device of claim 1, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer comprises Boron."

Claim 7 was taught or suggested by Bowen in view of Sunai or Parkin and optionally Soukup. EX1024 ¶¶182-94; *supra* §VI.A. The claim does not specify any molecular composition or stoichiometry of the claimed "ferromagnetic material layer [that] comprises Boron," and thus any ferromagnetic material layer including boron satisfies it. EX1017 at 10:20-22; EX1024 ¶183; *Mars v. H.J. Heinz*, 377 F.3d 1369, 1376 (Fed. Cir. 2004). CoFeB and FeCoB refer to the same alloy. EX1024 ¶183.

As explained for Claim 1[a], Bowen taught an Fe electrode and an FeCo electrode as its first and second ferromagnetic material layers, respectively. *Supra* §VI.A.2. One of skill would have found it obvious to replace either or both of Bowen's Fe or FeCo electrodes with a ferromagnetic layer including boron, such as CoFeB as taught by Sunai. EX1030 ¶¶28 (teaching CoFeB electrode by adding B

to Co_9Fe), 24 (teaching "ferromagnetic layer 4 is represented by the general formula $(CoFe)_{100-x}Y_x$" and specifying Y is an "element selected from the group consisting of B" or other elements); *id.* ¶¶25-29; EX1024 ¶185. Cobalt and iron were known ferromagnetic materials. EX1030 ¶33; EX1026 at 1655; EX1024 ¶185.

One of skill would have been motivated to replace either or both of Bowen's first and second electrodes with CoFeB to increase TMR and lower H_f and H_c. EX1055 at 2270 ("[I]t is natural to replace both the free and pinned layers to CoFeB to further increase the TMR value."); 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 ¶189. 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 Int'l v. Teleflex*, 550 U.S. 398, 416 (2007).

Bowen sought to increase TMR in its MgO MTJ, EX1026 at 1655, 1657, and understood that the properties of the MTJ's electrodes contributed to improve the tunneling and hence TMR of its device, EX1026 at 1657; EX1024 ¶188. A skilled artisan knew that using CoFeB electrodes improved TMR and lowered H_f and H_c. EX1024 ¶¶187, 189. CoFeB was known to increase TMR compared to CoFe, EX1030 ¶¶27-28 (describing improvements to TMR by adding B to CoFe), and

CoFe was known to obtain better results than Fe, EX1035 at 3274; *see also* EX1061 at Abstract ("CoFe-based junctions (R x A ~ 500 $\Omega.\mu m^2$) have lower TMR (~35%) and larger H_f (~5-6 Oe) and H_c (~12-14 Oe) [compared to CoFeB-based junctions]."); EX1024 ¶¶187, 189. This combination was both desirable and predictable because other researchers obtained similar results. *E.g.*, EX1055 at 2269-70 (The "benefit of using CoFeB is multifold" including "a higher TMR value."); EX1056 ¶¶39 (When the "ferromagnetic layer" is "comprised of a CoFeB alloy," it "exhibits a larger TMR ratio."), 78, 103-04, Fig. 7; EX1024 ¶¶187, 189.

One of skill would have looked to Sunai's teachings to improve Bowen's MTJ because both Bowen and Sunai focused on improving TMR of magnetoresistive devices, a problem to which the '909 Patent was directed. EX1026 at Abstract, 1655; EX1030 at Abstract, ¶¶1, 10; EX1017 at Abstract, 1:44-2:39. Both were directed to improving MRAM memory performance, as was the '909 Patent. EX1026 at 1655; EX1030 at Figs. 4-5, ¶¶1, 4, 37-40; EX1017 at 3:1-4; EX1024 ¶186. Both used ferromagnetic alloy electrodes. EX1026 at Abstract, 1655; EX1030 ¶¶24, 35; EX1024 ¶186. Because it was known 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 TMR in Bowen's MTJ. EX1024 ¶194; EX1030 ¶¶24-29; EX1055 at 2269-70; EX1056 ¶¶39, 78.

Alternatively, this limitation is also obvious over Bowen in view of Parkin. EX1024 ¶¶190-94. Parkin taught a ferromagnetic "CoFeB layer 175," as shown in Fig. 3A below:

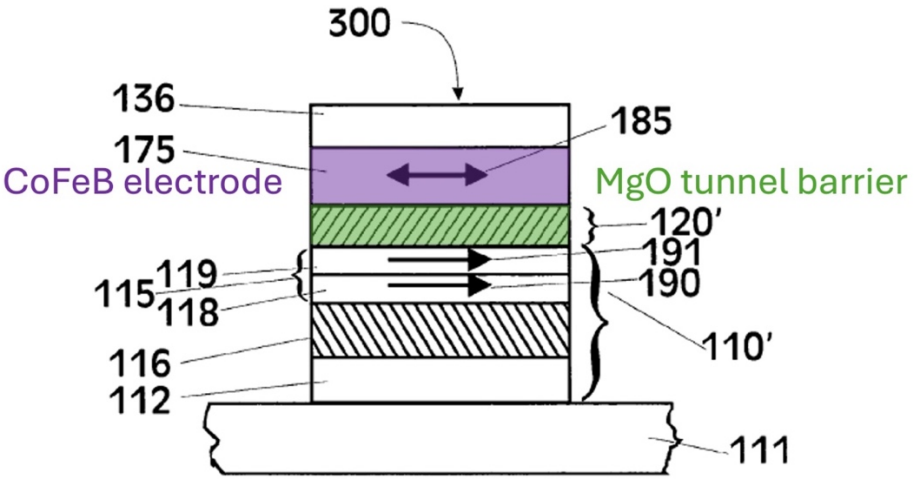


FIG. 3A

EX1062 at Fig. 3A (annotated), 19:16 (describing "the CoFeB layer 175" in Fig. 3A); EX1024 ¶¶190-91. Parkin's CoFeB layer 175 adjoins the "MgO crystalline layer 120'" in Figure 3A. EX1062 at 19:16-17.

As explained for Bowen and Sunai, one of skill would have been motivated to replace either or both of Bowen's electrodes with CoFeB to increase TMR and lower H_f and H_c. EX1055 at 2270 ("[I]t is natural to replace both the free and pinned layers to CoFeB to further increase the TMR value."); EX1056 ¶¶67-68; EX1035 at 3274; EX1024 ¶192; *KSR*, 550 U.S. at 416 ("combination of familiar elements" is obvious). Parkin itself teaches that the top and bottom electrodes in Figure 3A may

be "inverted." EX1062 at 17:7-10.

One of skill would have also looked to Parkin's teachings to improve Bowen's MTJ because both Bowen and Parkin focused on improving TMR of magnetoresistive devices, a problem to which the '909 Patent was directed. EX1026 at Abstract, 1655; EX1062 at 1:18-21 ("[T]his invention relates to an improved MTJ exhibiting high tunneling magnetoresistance…"); EX1017 at Abstract, 1:37-2:39; EX1024 ¶193. Both were directed to improving MRAM memory performance, as was the '909 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."); EX1017 at 3:1-4; EX1024 ¶193. Both used ferromagnetic alloy electrodes. EX1026 at Abstract, 1655; EX1062 at 1:18-21 ("[T]his invention relates to an improved MTJ… with one or more electrodes formed from amorphous ferromagnetic materials."); EX1024 ¶193.

H. Claim 8: "The magnetoresistive device of claim 1, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer is partially or entirely crystallized."

This claim was taught or suggested by Bowen alone or in view of Soukup for the reasons provided in Claim 1. *Supra* §VI.A; EX1024 ¶¶195-200.

As explained for Claim 1[a], Bowen taught epitaxial Fe and FeCo electrodes as its first and second ferromagnetic material layers, respectively. *Supra* §VI.A.2. Bowen taught that its lower Fe and upper CoFe bcc electrodes were partially or

entirely crystallized: "We present tunneling experiments on Fe(001)/MgO(20 Å)/FeCo(001) ***single-crystal*** epitaxial junctions of high quality…." EX1026 at Abstract; *id*. at 1655-56; EX1024 ¶¶197-98. "This low-temperature deposition and subsequent annealing process leads to an optimal Fe electrode in terms of crystallinity, continuity, and interface sharpness after annealing." EX1026 at 1655. Bowen experimentally confirmed "the crystallinity and high quality" of his MgO MTJ. EX1026 at 1656; *id*. at 1655 ("$Fe_{50}Co_{50}$ and Fe layers are bcc structured…."), Fig. 1; EX1024 ¶¶197-98.

I. Claim 9

Claim 9 would have been obvious over Bowen in view of Soukup.

1. Claim 9[preamble]: "A magnetoresistive device comprising a magnetic tunnel junction structure comprising:"

Supra Claim 1[preamble], §VI.A.1; *see also* Claims 9[a]-9[c], §§VI.A.2-VI.A.4; EX1024 ¶201.

2. Claim 9[a]: "first and second ferromagnetic material layer; and"

Supra Claim 1[a], §VI.A.2; EX1024 ¶202.

3. Claim 9[b]: "a tunnel barrier layer between the first and second ferromagnetic material layers,"

Supra Claim 1[b], §VI.A.3; EX1024 ¶203.

4. Claim 9[c]: "wherein said tunnel barrier layer comprises magnesium oxide and has a barrier height in a range of 0.1 eV to 0.85 eV."

Supra Claims 1[c] and 5, §§VI.A.4, VI.E; EX1024 ¶204.

J. Claim 10: "The magnetoresistive device of claim 9, wherein the tunnel barrier layer comprises partially or fully crystalline magnesium oxide."

Claim 10 would have been obvious over Bowen in view of Soukup. EX1024 ¶¶205-06. As explained in Claim 1[c], Bowen disclosed a "single-crystal" MgO barrier layer. EX1026 at Abstract, 1655-56; *supra* §§VI.A.4, VI.I (Claims 1[c], 9); EX1024 ¶206.

K. Claim 11: "The magnetoresistive device of claim 10, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer is partially or entirely crystallized."

Supra Claims 8 and 10, §§VI.H, VI.J; EX1024 ¶207.

L. Claim 12: "The magnetoresistive device of claim 11, wherein the barrier height is in a range of 0.2 eV to 0.5 eV."

Supra Claims 6 and 11, §§VI.F, VI.K; EX1024 ¶208.

M. Claim 13: "The magnetoresistive device of claim 11, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer exhibits a body-centered cubic (BCC) structure."

Claim 13 would have been obvious over Bowen in view of Soukup. EX1024 ¶¶209-12; *supra* §VI.K (Claim 11). As explained for Claim 1[a], Bowen taught Fe and FeCo electrodes as its first and second ferromagnetic material layers,

respectively. *Supra* §VI.A.2. Bowen taught that his "$Fe_{50}Co_{50}$ and Fe layers are ***bcc structured***." EX1026 at 1655, Fig. 1; EX1024 ¶211.

N. Claim 14: "The magnetoresistive device of claim 11, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer comprises Cobalt and Iron."

Claim 14 would have been obvious over Bowen in view of Soukup. EX1024 ¶¶213-14; *supra* §VI.K (Claim 11). As explained for Claim 1[a], Bowen taught an iron cobalt (FeCo) electrode as its second ferromagnetic material layer. *Supra* §VI.A.2; EX1024 ¶213.

O. Claim 15

Claim 15 would have been obvious over Bowen in view of Soukup.

1. Claim 15[preamble]: "A magnetoresistive device comprising:"

Supra Claim 1[preamble], §VI.A.1; EX1024 ¶215.

2. Claim 15[a]: "a first ferromagnetic material layer;"

Supra Claim 1[a], §VI.A.2; EX1024 ¶216.

3. Claim 15[b]: "a tunnel barrier comprising magnesium oxide and having a barrier height in a range of 0.2 eV to 0.5 eV; and"

Supra Claims 1[c] and 6, §§VI.A.4, VI.F; EX1024 ¶217.

4. Claim 15[c]: "a second ferromagnetic material layer disposed on the tunnel barrier layer and separated from the first ferromagnetic material layer by the tunnel barrier layer."

This limitation is disclosed or suggested by Bowen for the same reasons provided in Claims 1[a] and 1[b]. *Supra* §§VI.A.2, VI.A.3; EX1024 ¶¶218-21.

As explained in Claim 1[b], the "tunnel barrier" layer refers to "an oxide [that] is sandwiched between a first and a second electrode made of a ferromagnetic metal." EX1017 at 1:54-57; *supra* §VI.A.3. A skilled artisan would understand that the "a second ferromagnetic material layer disposed on the tunnel barrier layer" limitation refers to the ferromagnetic material layer positioned on top of the barrier layer and the "first ferromagnetic material layer" refers to the bottom ferromagnetic material layer positioned below the tunnel barrier layer. EX1024 ¶219.

Bowen disclosed this limitation. 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"). Bowen's "FeCo" is the "top electrode" that is positioned on top of the "MgO barrier." EX1026 at 1655, Fig. 1. Bowen's "Fe" is the "bottom electrode" that is positioned below the MgO barrier such that the FeCo top electrode is separated from the Fe bottom electrode by the MgO barrier. EX1024 ¶¶220-21.

P. Claim 16: "The magnetoresistive device of claim 15, wherein the tunnel barrier layer comprises partially or fully crystalline magnesium oxide."

Supra Claims 1[c] and 15, §§VI.A.4, VI.O; EX1024 ¶222.

Q. Claim 17: "The magnetoresistive device of claim 16, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer is partially or entirely crystallized."

Supra Claims 8 and 16, §§VI.H, VI.P; EX1024 ¶223.

R. Claim 18: "The magnetoresistive device of claim 17, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer exhibits a body-centered cubic (BCC) structure."

Supra Claims 13 and 17, §§VI.M, VI.Q; EX1024 ¶224.

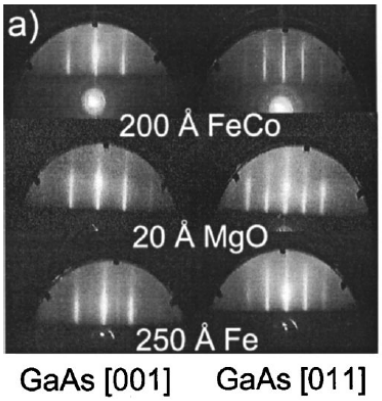
S. Claim 19: "The magnetoresistive device of claim 17, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer comprises Cobalt and Iron."

Supra Claims 14 and 17, §§VI.N, VI.Q; EX1024 ¶225.

T. Claim 20: "The magnetoresistive device of claim 15, wherein the tunnel barrier layer has a thickness less than 10 nm."

Claim 20 is obvious over Bowen in view of Soukup. *Supra* §VI.O (Claim 15); EX1024 ¶¶226-27.

As shown at right, Bowen disclosed a "20 Å" (or 2 nm) MgO barrier layer that is "less than 10 nm" thick. EX1026 at Abstract, 1656, Fig. 1 (excerpted); EX1024 ¶¶226-27.



VII. GROUND 2: CLAIMS 1-20 ARE OBVIOUS OVER NAGAHAMA (AND SUNAI OR PARKIN AND/OR SOUKUP)

Nagahama disclosed a series of MTJ embodiments focused on a basic structure of a ferromagnetic layer on top of an insulating layer on top of an ultrathin ferromagnetic layer on top of an underlayer. *E.g.*, EX1027 at 10 (claim 1), ¶¶73-74 (describing same arrangement with MgO barrier layer); *see id.* ¶75 (describing the various layers of the magnetoresistive element of Figure 17 including the MTJ and underlayers and insulating layer); EX1024 ¶231. Additionally, Nagahama disclosed that "[t]he present invention relates to… a tunnel magnetoresistive element whose crystal orientation is set to the (001) direction of a body-centered cubic lattice, a face-centered cubic lattice, or a tetragonal lattice." EX1027 ¶1; EX1024 ¶231. It would have been obvious to a skilled artisan to use Nagahama's teachings regarding MTJs to form a single structure satisfying the challenged claims as discussed below.

A. Claim 1

Claim 1 would have been obvious over Nagahama alone or alternately in view of Soukup.

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

To the extent limiting, Nagahama taught or suggested "tunnel magnetoresistive element[s]" with a tunnel barrier junction structure comprising a

multi-layer material stack as claimed. EX1027 ¶¶73-76, Abstract, Claim 1, Figs. 3, 17; EX1024 ¶¶229-35; *infra* §VII.A.

As explained in Ground 1, MTJs were well known in the art. EX1024 ¶¶234-35; *supra* §§II.B, VI.A.1.

2. Claim 1[a]: "first and second ferromagnetic material layer; and"

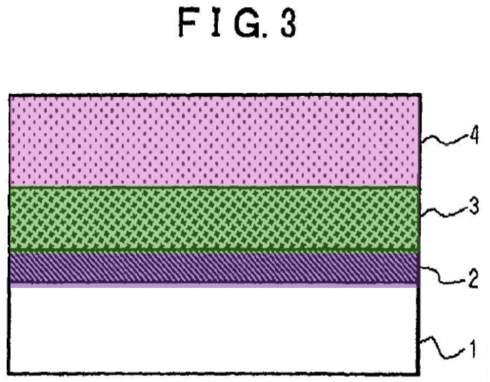
This limitation was taught or suggested by Nagahama. EX1024 ¶¶236-41.

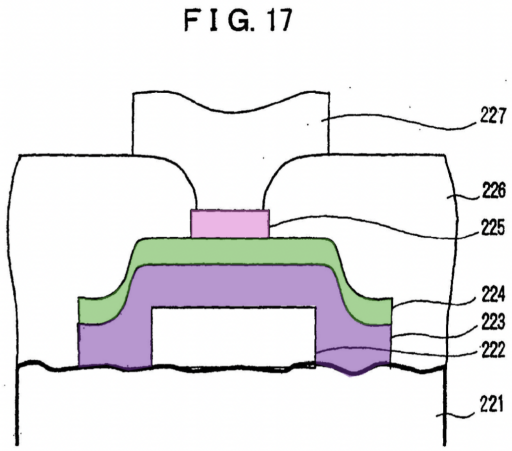
As explained in Ground 1, this limitation refers to an "electrode made of a ferromagnetic metal" with the "first" layer referring to the lower ferromagnetic electrode and "second" layer referring to the upper electrode as specified in Claim 1[b]. *Supra* §VI.A.2 (Claim 1[a]); EX1024 ¶237.

Nagahama disclosed and depicted:

- its "223, a **lower ferromagnetic electrode**" as the "first ferromagnetic material layer." EX1027 ¶76, Fig. 17; *see also id*. ¶¶ 73, 75; *see also id*. ¶22, Fig. 3 (describing the same relationships); EX1024 ¶¶238-40; and
- element "225, an **upper ferromagnetic electrode**" formed on the other side of tunnel barrier layer 224 as the claimed "second ferromagnetic material layer," EX1027 ¶76, Fig. 17; *id.* at Abstract, ¶¶21-22, 75; EX1024 ¶¶238-40.

Both of these layers are depicted in Nagahama's figures below:





EX1027 at Figs. 3, 17 (Fig. 3 excerpted, both annotated).

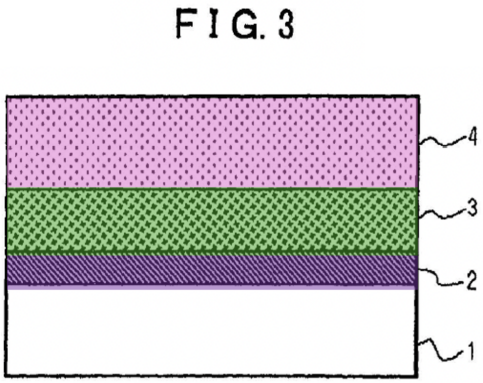
Nagahama teaches that these ferromagnetic electrodes can be made of Fe or CoFe respectively, EX1027 ¶28, and provides various examples of "ferromagnetic metals, such as Fe, Co, Ni, or an alloy of these metals," EX1027 ¶31; *see id*. ¶¶61, 68. EX1024 ¶240.

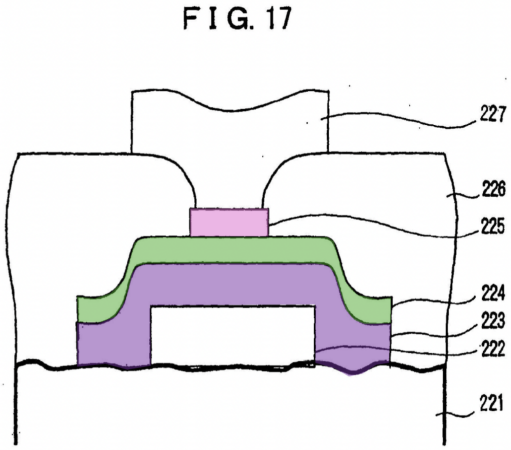
As explained in Ground 1, MTJs with ferromagnetic layers were conventional. EX1024 ¶241; *supra* §§II.D.1, VI.A.2 (Claim 1[a]).

3. Claim 1[b]: "a tunnel barrier layer between the first and second ferromagnetic material layers such that the tunnel barrier layer is above the first ferromagnetic material layer and below the second ferromagnetic material layer,"

Nagahama taught or suggested this limitation. EX1024 ¶¶242-46. Its paragraphs 73-74 embodiment described a "tunnel magnetoresistive element" including "a (001)-highly-oriented MgO barrier layer." EX1027 ¶¶73-74. Such an arrangement is depicted in Figures 3 and 17 as well. EX1027 ¶¶21-22, 75-76;

EX1024 ¶¶239-40, 244. In Figures 3 and 17, 1 and 222 represent a substrate (or underlayer); 2 and 223 represent a **lower ferromagnetic layer**; 3 and 224 represent a **barrier layer**; and 4 and 225 represent an **upper ferromagnetic layer**. EX1027 ¶¶21-22, 75-76; EX1024 ¶240.





EX1027 at Figs. 3, 17 (Fig. 3 excerpted, both annotated).

As explained for Claim 1[a] in this Ground, Nagahama taught or suggested a tunnel barrier layer between the first and second ferromagnetic material layers. *Supra* §VII.A.2; EX1024 ¶245. In the example of paragraphs 73-74, Nagahama taught that its "(001)-highly-oriented MgO barrier layer" was above the "(001)-highly-oriented ***lower*** ferromagnetic electrode layer" and below the "(001)-highly-oriented ***upper*** ferromagnetic electrode layer." EX1027 ¶¶73-74; *see also id.* ¶¶21-22, Fig. 3 (describing same arrangement for Fig. 3), ¶¶75-76, Fig. 17 (describing same arrangement for Fig. 17); EX1024 ¶¶244-45. Nagahama's multiple embodiments describing the same basic structure confirm its teachings to a skilled

artisan. *See id*. Consequently, Nagahama also disclosed an MTJ with a tunnel barrier between its first and second ferromagnetic material layers. EX1024 ¶¶244-45.

As explained in Ground 1, a tunnel barrier between two ferromagnetic layers was conventional. *Supra* §§VI.A.3 (Claim 1(b)), II.B; EX1024 ¶246.

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

Nagahama alone or in view of Soukup taught or suggested this limitation. EX1024 ¶¶247-53. As explained for Claim 1[b], Nagahama taught "a (001)-highly-oriented MgO barrier layer." EX1027 ¶73; EX1024 ¶248; *supra* §VII.A.3. Nagahama's MgO(001) barrier layer was polycrystalline. *Id*. Because single-crystal layers have the same orientation throughout the crystalline lattice, "highly-oriented" is a term that describes the predominant orientation of a polycrystalline layer containing many crystals. EX1024 ¶249; EX1040 at 2842 (MgO "polycrystalline structures" have "preferred orientation."). Describing "a (001)-highly-oriented MgO barrier layer," EX1027 ¶73, confirms Nagahama's MgO(001) barrier was polycrystalline, EX1024 ¶¶248-49.

Nagahama inherently satisfied MgO_x where $0<x<1$, a mathematical notation indicating oxygen vacancy defects in the MgO layer. EX1024 ¶¶250-51; EX1017 at 6:44-46, 7:18-19; EX1002 at 168; EX1008 at 198; *supra* §II.E. MgO with oxygen

vacancy defects was inherently MgO_x where $0<x<1$ because x has to be greater than 0 to constitute MgO and less than 1 to constitute nonstoichiometric MgO with oxygen vacancies. EX1024 ¶¶133, 250-51. One of skill would have understood that Nagahama's MgO tunnel barrier necessarily included oxygen vacancy defects because these defects occur in all MgO barriers. EX1042 at 162; EX1008 at 198; EX1024 ¶251; *supra* §II.E.

Alternatively, Nagahama in view of Soukup also taught 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 ¶252. Soukup determined that increasing oxygen vacancy defects reduced tunnel barrier height. EX1028 at 3232. One of skill would thus have been motivated to apply Soukup's teachings about oxygen vacancy defects to Nagahama's MgO MTJ to improve tunneling current, increase TMR, and enhance MRAM performance for the same reasons as explained in Claim 5. *Infra* §VII.E; EX1024 ¶253; *id.* ¶¶273-86.

B. Claim 2: "The magnetoresistive device of claim 1, wherein 0.9<x<1."

This claim would have been obvious over Nagahama in view of Soukup. *Supra* §VII.A (Claim 1); EX1024 ¶¶254-65. Oxygen vacancy defects between 0.9 and 1 for a MgO barrier were known. *E.g.*, EX1037 at 3; EX1024 ¶¶139, 255-57.

As explained in detail in Ground 1, the claimed range "0.9<x<1" was an obvious result-effective variable. *Supra* §VI.B (Claim 2). Skilled artisans like Bowen and Nagahama, were already interested in increasing TMR to achieve better performing MRAM. *Id.*; EX1027 ¶82 ("Industrial Applicability" of the invention was to "a magnetic sensor of a pickup head of a hard disk drive or a ferromagnetic random access memory."). For the same reasons explained in Ground 1, the conditions of this claim limitation were disclosed in the prior art. *DuPont*, 904 F.3d at 1006; EX1024 ¶¶257, 259; *supra* §VI.B (Claim 2).

As provided in Claim 1[c], Nagahama's MgO barrier layer necessarily included oxygen vacancy defects because these defects occur in all MgO barriers. EX1042 at 162; EX1024 ¶261; EX1008 at 198; *supra* §§VII.A.4; II.E. 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 ¶252. As also explained in Claim 1[c], MgO with oxygen vacancy defects is inherently MgO_x

where $0<x<1$. EX1024 ¶256. Thus, MgO_x where $0.9<x<1$ is merely a subrange within that which is disclosed inherently by Nagahama and Soukup and is thus overlapping and presumptively obvious. *DuPont*, 904 F.3d at 1006; *Arbutus*, 65 F.4th at 665.

Nagahama taught an MTJ including "a (001)-highly-oriented lower ferromagnetic electrode layer, a (001)-highly-oriented MgO barrier layer, and a (001)-highly-oriented upper ferromagnetic electrode layer." EX1027 ¶73; *id.* ¶¶75-76; EX1024 ¶261. Nagahama together with the '909 Patent's sole inventor, Dr. Yuasa, reported obtaining a TMR "of more than 90%" with this MTJ embodiment, EX1027 at 1, ¶74, and reported depositing the MgO underlayer using sputtering, *id.* ¶¶57, 62 (third group of the present invention), wherein the MgO underlayer initially was grown amorphous, but then formed an "MgO(001)-oriented highly oriented crystal layer." *Id.* ¶58; *see also id.* ¶¶64-65; EX1024 ¶261. Thus, Nagahama's group disclosed using sputtering to create a "(001)-highly-oriented MgO" layer. *Id.*; EX1024 ¶261.

Indeed, the '909 Patent disclosed that "it should be obvious that" either electron-beam evaporation or sputtering were possible MgO deposition methods. EX1017 at 9:45-48. Given that Nagahama obtained a TMR of more than 90%, EX1027 ¶74, which was a higher TMR than purportedly measured using the '909 Patent's first embodiment, EX1017 at 8:15-19, Fig. 6, Nagahama's MgO barrier

layer fabrication method was sufficient to achieve the object of the '909 Patent's claimed invention. *DuPont*, 904 F.3d at 1006; EX1024 ¶262. Additionally, Soukup's MgO layer was deposited using electron-beam evaporation like the '909 Patent's first MTJ device embodiment, as explained in Ground 1. EX1017 at 6:19-26, 6:50-54; EX1024 ¶153; *supra* §VI.B (Claim 2).

While Nagahama and Soukup did not expressly quantify the oxygen vacancy defects in their respective MgO layers, as previously explained in Claim 1[c] of this Ground, one of skill understood that oxygen vacancy defects necessarily resulted in an MgO_x barrier with $0<x<1$, EX1024 ¶256; *supra* §II.E, that these defects impacted barrier height, EX1028 at Abstract, 3232; EX1024 ¶¶154, 257, and that reducing barrier height was desirable for obtaining higher TMR, EX1044 at 1; EX1046 at 1; EX1024 ¶¶168-69, 257. Thus, the "$0.9<x<1$" claimed range was presumptively obvious as a result-effective parameter. *Pfizer*, 94 F.4th at 1348; *Arbutus*, 65 F.4th at 665; *supra* §VI.B (Claim 2 in Ground 1).

Also as explained in Ground 1, Soukup's barrier height of 0.33 eV was inherently within the range disclosed by the '909 Patent as indicative of "oxygen vacancy defects," and was not new or unexpected but speculative. *Supra* §VI.B (Claim 2).

C. Claim 3: "The magnetoresistive device of claim 2, wherein 0.98<x<1."

Claim 3 was obvious over Nagahama in view of Soukup for the reasons provided in Claims 1-2. EX1024 ¶¶266-68; *supra* §§VII.A-VII.B.

As explained for Claim 2, this claim would have also been obvious because the claimed MgO_x oxygen vacancy defect range, "0.98<x<1," overlapped with the 0<x<1 range inherent in Nagahama and Soukup; was a result-effective variable, which is not critical to the object of the invention; was within a skilled artisan's grasp; and was achievable through routine experimentation. EX1024 ¶267; EX1016 at 91; *supra* §VII.B. Additionally, as explained in Claim 2 in this Ground, according to the '909 Patent, its claimed oxygen vacancy defect ranges are inherent in Soukup. *See Arbutus*, 65 F.4th at 662.

The "0.98<x<1" claimed range was also speculative for the same reasons explained for Claim 2. EX1024 ¶268; *supra* §VII.B.

D. Claim 4: "The magnetoresistive device of claim 3, wherein 0.99<x<1."

This claim was obvious over Nagahama in view of Soukup for the reasons provided in Claims 1-3. EX1024 ¶¶269-71; *supra* §§VII.A-VII.C.

Additionally, this claimed MgO layer oxygen vacancy range was also obvious because it overlapped with the 0<x<1 range inherent in Nagahama and Soukup and was a result-effective variable for the same reasons described in Claims 2-3.

EX1024 ¶270; EX1016 at 91; *supra* §§VII.B-VII.C. Additionally, as explained for Claims 2-3, the claimed oxygen vacancy defect ranges are both inherent in Soukup and speculative. EX1024 ¶271; *Arbutus*, 65 F.4th at 662; *supra* §§VII.B-VII.C.

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

Claim 5 was obvious over Nagahama in view of Soukup. EX1024 ¶¶272-86; *supra* §VII.A (Claim 1).

Nagahama in view of Soukup taught or suggested an MgO tunnel barrier height for an MgO barrier layer in the claimed range of 0.1 to 0.85 eV. EX1024 ¶¶272-73. Nagahama taught an MgO MTJ. EX1027 ¶¶73-74, Abstract, Figs. 3, 17. Soukup observed a "barrier height" of "***about 0.33 eV***" for its MgO barrier. EX1028 at Abstract; *id.* at 3231-32, Fig. 5, Table I; EX1024 ¶273.

As explained in Ground 1, one of skill reading Soukup understood there was a relationship between oxygen vacancy defects and barrier height. *Supra* §VI.E (Claim 5); EX1024 ¶274.

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 Nagahama's MgO barrier. EX1028 at Abstract, 3232, 3236; EX1024 ¶¶275-77, 281. As explained for Claim 5 in Ground 1, TMR was an "important parameter" and of high interest for improving MRAM performance, and lowering the resistance (barrier

height) for parallel electrons would improve TMR. EX1055 at 2269, 2271; EX1035 at 3273; EX1027 ¶2; EX1024 ¶276; *supra* §VI.E. Nagahama's stated goal was to improve TMR in its MTJ. EX1027 ¶¶6, 15; *see also id*. ¶¶3-8; EX1024 ¶277. Nagahama sought to increase TMR by modifying properties of the MgO barrier layer. EX1027 ¶¶15-17. Indeed, Nagahama discussed prior research on increasing TMR in MgO barriers by Mathon, Bowen, and others. EX1027 ¶¶2-14; EX1024 ¶281.

As explained in Ground 1, Butler and Mathon taught that MgO barriers improved TMRs due to improved symmetry facilitating tunneling of parallel electrons, and one of skill would have been motivated to explore lower barrier heights to accomplish that. EX1044 at 1; EX1046 at 1; EX1024 ¶¶170-71; *supra* §VI.E. One of skill seeking to improve Nagahama's MTJ would have looked to Soukup's teachings about how defects lowered MgO barrier height. EX1024 ¶281. Indeed, both Nagahama and Soukup studied tunneling and other properties of MgO barriers and were focused on improving tunneling devices, the problem to which the '909 Patent was directed. EX1027 ¶¶2-4, 13-15; EX1028 at 3229-30; EX1017 at Abstract, 1:37-2:39; EX1024 ¶281.

One of skill would have had a reasonable expectation of success in achieving Soukup's tunnel barrier height in Nagahama's MTJ. EX1024 ¶282. Soukup had already shown that an MgO barrier achieved a height of 0.33 eV, EX1028 at Abstract,

and that the barrier height was varied by adjusting the oxygen vacancy defects in the MgO barrier layer, EX1028 at Abstract, 3232, 3236; EX1024 ¶282. One of skill would have predictably followed this trail. *Id*.

For the same reasons explained in Ground 1, the claimed tunnel barrier height range of 0.1 to 0.85 eV would have been obvious and is also inherent, according to the '909 Patent. *Supra* §VI.E (Claim 5); EX1024 ¶¶175, 285.

F. Claim 6: "The magnetoresistive device of claim 5, wherein the barrier height of the tunnel barrier layer is in a range of 0.2 eV to 0.5 eV."

Claim 6's overlapping barrier height range was obvious over Nagahama in view of Soukup for the reasons provided in Claim 5. *Supra* §VII.E; EX1024 ¶287.

G. Claim 7: "The magnetoresistive device of claim 1, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer comprises Boron."

Claim 7 is obvious over Nagahama in view of Sunai or Parkin and optionally Soukup. *Supra* §VII.A (Claim 1); EX1024 ¶¶288-97.

Again, because the claim doesn't specify, any CoFeB alloy satisfies it. *Supra* §VI.G (Ground 1); EX1024 ¶289. As explained in Claim 1[a], Nagahama taught a first and second ferromagnetic material layer. *Supra* §VII.A.2. One of skill would have found it obvious to replace either or both of Nagahama's ferromagnetic layers with a ferromagnetic material layer, including boron CoFeB, as taught by Sunai. EX1030 ¶¶24-29.

One of skill would have been motivated to replace either or both of Nagahama's electrodes with CoFeB to increase TMR and lower H_f and H_c. EX1055 at 2270 ("[I]t is natural to replace both the free and pinned layers to CoFeB to further increase the TMR value."); EX1056 ¶¶67-68; EX1035 at 3274; EX1061 at Abstract; EX1024 ¶¶291, 293. Indeed, Nagahama sought to "obtain a high magnetoresistive effect" in its MgO MTJ, EX1027 ¶6, and understood that the properties of the ferromagnetic electrodes impacted TMR, EX1027 ¶23; EX1024 ¶293. Such a "combination of familiar elements" is obvious. *KSR*, 550 U.S. at 416.

One of skill would have looked to Sunai's teachings to improve Nagahama's MTJ. EX1024 ¶294. Both Nagahama and Sunai focused on improving TMR of magnetoresistive devices, a problem to which the '909 Patent was directed. EX1027 ¶¶6, 15; EX1030 at Abstract, ¶¶1, 10; EX1017 at Abstract, 1:44-2:39. Both were directed to improving MRAM memory performance, as was the '909 Patent. EX1027 ¶¶3, 49; EX1030 at Figs. 4-5, ¶¶1, 4, 37-40; EX1017 at 3:1-4; EX1024 ¶294. Both used the same MgO barrier layer and similar ferromagnetic alloy electrodes. EX1027 ¶¶6, 73; EX1030 ¶¶24, 35; EX1024 ¶294. Because it was known that CoFeB alloy electrodes had been successfully used as electrodes for MTJs, one of skill would have found it to be a straightforward, predictable, and desirable improvement to Nagahama's MTJ. EX1024 ¶295; EX1030 ¶¶24-29; EX1055 at 2269-70; EX1056 ¶¶39, 78.

Alternatively, Claim 7 is obvious over Nagahama in view of Parkin. EX1024 ¶¶296-97. As explained in Ground 1, Parkin taught a ferromagnetic CoFeB layer. *Supra* §VI.G (Claim 7); EX1062 at 19:15-22; EX1024 ¶296.

As discussed, Parkin's disclosure satisfies this limitation, and one of skill would have found it obvious to replace either or both of Nagahama's ferromagnetic material layers with Parkin's layer. *Supra* §VI.G (Ground 1, Claim 7).

One of skill would have also looked to Parkin's teachings to improve Nagahama's MTJ because both Nagahama and Parkin focused on improving TMR of magnetoresistive devices, a problem to which the '909 Patent was directed. EX1027 ¶¶6, 15; EX1062 at 1:18-21 ("[T]his invention relates to an improved MTJ exhibiting high tunneling magnetoresistance…."); EX1017 at Abstract, 1:37-2:39. Both were directed to improving MRAM memory performance, as was the '909 Patent. EX1027 ¶¶3, 49; 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."); EX1017 at 3:1-4; EX1024 ¶297. Both used the same MgO barrier layer and similar ferromagnetic alloy electrodes. EX1027 ¶¶6, 73; EX1062 at 1:18-21 ("[T]his invention relates to an improved MTJ… with one or more electrodes formed from amorphous ferromagnetic materials."); EX1024 ¶297. Because it was known 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 TMR, H_f, and H_c in Nagahama's MTJ. EX1024 ¶295; EX1062 at 18:49-51, 18:63-19:10; EX1055 at 2269-70; EX1056 ¶¶39, 78; EX1060 at Abstract.

H. Claim 8: "The magnetoresistive device of claim 1, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer is partially or entirely crystallized."

Claim 8 was taught or suggested by Nagahama alone or in view of Soukup. *Supra* §VII.A (Claim 1); EX1024 ¶¶298-302.

Nagahama disclosed that each of its ferromagnetic material layers were polycrystalline: "a (001)-highly-oriented" electrode layer. EX1027 ¶73; *see also id.* ¶76; EX1024 ¶¶299-300. One of skill would have known that polycrystalline electrodes were partially or entirely crystallized. Nagahama taught that its ferromagnetic layers were crystallized. *See* EX1027 ¶1 ("set to the (001) direction of a ***body-centered cubic lattice***"); *id.* at 11 (claim 20: "by using the underlayer so that a ferromagnetic electrode layer is oriented in the (001) direction of a ***body-centered cubic lattice***"); EX1024 ¶¶301-02.

I. Claim 9

Claim 9 would have been obvious over Nagahama in view of Soukup.

1. Claim 9[preamble]: "A magnetoresistive device comprising a magnetic tunnel junction structure comprising:"

Supra Claim 1[preamble], §VII.A.1; *see also* Claims 9[a]-9[c], §§VII.I.2-VII.I.4; EX1024 ¶303.

2. Claim 9[a]: "first and second ferromagnetic material layer; and"

Supra Claim 1[a], §VII.A.2; EX1024 ¶304.

3. Claim 9[b]: "a tunnel barrier layer between the first and second ferromagnetic material layers,"

Supra Claim 1[b], §VII.A.3; EX1024 ¶305.

4. Claim 9[c]: "wherein said tunnel barrier layer comprises magnesium oxide and has a barrier height in a range of 0.1 eV to 0.85 eV."

Supra Claim 1[c] and Claim 5, §§VII.A.4, VII.E; EX1024 ¶306.

J. Claim 10: "The magnetoresistive device of claim 9, wherein the tunnel barrier layer comprises partially or fully crystalline magnesium oxide."

Claim 10 was obvious over Nagahama in view of Soukup. EX1024 ¶¶307-08. As explained for Claim 1[c], Nagahama disclosed a polycrystalline MgO barrier layer. EX1027 ¶73; *supra* §§VII.A.4, VII.I (Claims 1[c], 9); EX1024 ¶308.

K. Claim 11: "The magnetoresistive device of claim 10, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer is partially or entirely crystallized."

Supra Claims 8 and 10, §§VII.H, VII.J; EX1024 ¶309.

L. Claim 12: "The magnetoresistive device of claim 11, wherein the barrier height is in a range of 0.2 eV to 0.5 eV."

Supra Claims 6 and 11, §§VII.F, VII.K; EX1024 ¶310.

M. Claim 13: "The magnetoresistive device of claim 11, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer exhibits a body-centered cubic (BCC) structure."

Claim 13 was obvious over Nagahama in view of Soukup. EX1024 ¶¶311-12; *supra* §VII.K (Claim 11). As explained in Claim 1[a], Nagahama taught ferromagnetic material layers. *Supra* §VII.A.2. Nagahama explained that its MTJ used "a ferromagnetic electrode layer… oriented in the (001) direction of a ***body-centered cubic lattice***, a face-centered cubic lattice, or a tetragonal lattice." EX1027 ¶18 (item [20]); *id.* ¶¶1, 23; EX1024 ¶312. To the extent IP Bridge asserts that this disclosure does not apply to the paragraphs 73-74 embodiment, it would have been obvious to a skilled artisan to generate these ferromagnetic layers in bcc structure with a reasonable likelihood of success because Nagahama itself taught that bcc structure was desirable to achieve "a large magnetoresistive effect." EX1027 ¶¶18 (item [20]), 81 (item [F]); *id*. at 11 (claim 20); EX1024 ¶312.

N. Claim 14: "The magnetoresistive device of claim 11, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer comprises Cobalt and Iron."

Claim 14 was obvious over Nagahama in view of Soukup. EX1024 ¶¶313-14; *supra* §VII.K (Claim 11). As explained in Claim 1[a], Nagahama taught a cobalt iron "CoFe upper electrode" as its second ferromagnetic material layer. EX1027 ¶28; *supra* §VII.A.2; EX1024 ¶314.

O. Claim 15

Claim 15 was obvious over Nagahama in view of Soukup.

1. Claim 15[preamble]: "A magnetoresistive device comprising:"

Supra Claim 1[preamble], §VII.A.1; EX1024 ¶315.

2. Claim 15[a]: "a first ferromagnetic material layer;"

Supra Claim 1[a], §VII.A.2; EX1024 ¶316.

3. Claim 15[b]: "a tunnel barrier comprising magnesium oxide and having a barrier height in a range of 0.2 eV to 0.5 eV; and"

Supra Claims 1[c] and 6, §§VII.A.4, VII.F; EX1024 ¶317.

4. Claim 15[c]: "a second ferromagnetic material layer disposed on the tunnel barrier layer and separated from the first ferromagnetic material layer by the tunnel barrier layer."

Supra Claims 1[a]-1[b], §§VII.A.2-VII.A.3; EX1024 ¶318.

P. Claim 16: "The magnetoresistive device of claim 15, wherein the tunnel barrier layer comprises partially or fully crystalline magnesium oxide."

Supra Claims 1[c] and 15, §§VII.A.4, VII.O; EX1024 ¶319.

Q. Claim 17: "The magnetoresistive device of claim 16, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer is partially or entirely crystallized."

Supra Claims 8 and 16, §§VII.H, VII.P; EX1024 ¶320.

R. Claim 18: "The magnetoresistive device of claim 17, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer exhibits a body-centered cubic (BCC) structure."

Supra Claims 13 and 17, §§VII.M, VII.Q; EX1024 ¶321.

S. Claim 19: "The magnetoresistive device of claim 17, wherein the first ferromagnetic material layer and/or the second ferromagnetic material layer comprises Cobalt and Iron."

Supra Claims 14 and 17, §§VII.N, VII.Q; EX1024 ¶322.

T. Claim 20: "The magnetoresistive device of claim 15, wherein the tunnel barrier layer has a thickness less than 10 nm."

Claim 20 is obvious over Nagahama in view of Soukup. *Supra* §VII.O (Claim 15); EX1024 ¶¶323-30.

Nagahama taught or suggested this limitation. Nagahama taught an "MgO barrier layer." EX1027 ¶73; *see also id*. ¶76, Fig. 17; EX1024 ¶324. Nagahama didn't specify the precise thickness of the MgO barrier layer in Figure 17, but taught that "(001)-highly-oriented MgO layer[s were] set in the range of 3 to 10 nm." EX1027 ¶18 (item [16]); *see also id*. ¶¶58, 66, 81 (item (B)); *id*. at 11 (claim 16); EX1024 ¶324. An MgO barrier thickness <10 nm was obvious over Nagahama, who cited (EX1027 ¶14) to both Bowen teaching a 2 nm (20Å) MgO barrier, EX1026 at Abstract, 1656, Fig. 1, and Mathon describing MgO barrier layers of 1.47–4.2 nm (7–20 atomic planes), EX1046 at 3; EX1024 ¶324.

To the extent the Board finds that Nagahama did not teach or suggest this limitation, one of skill would have been motivated to use a <10 nm tunnel barrier

layer with a reasonable expectation of success. Fabricating MgO layers under 10 nm thick was conventional according to Nagahama. EX1027 ¶¶18, 58, 66, 81; *id*. at 11 (claim 16); EX1024 ¶¶324-30. Barrier layers in that range were also known to desirably increase TMR, a problem to which both Nagahama and the '909 Patent were directed. *Supra* §VII.G (Claim 7); EX1026 at Abstract; EX1046 at 3; EX1038 at Abstract, 4725 (Moodera: observing "[l]arge magnetoresistance" with "1.2–2.0 nm" thick MgO tunnel barrier); EX1053 at 8041 (Mitani: reporting "large TMR" with 6.4 Å (0.64 nm) thick MgO layer); EX1024 ¶¶326-30. Indeed, Nagahama himself pointed to Bowen and Mathon's MTJs with <10 nm MgO barriers as achieving high TMR. EX1027 ¶14; EX1024 ¶326.

VIII. SECONDARY CONSIDERATIONS

Western Digital is unaware of any relevant secondary considerations of non-obviousness for the '909 Patent. EX1024 ¶331.

IX. 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); Director's Interim Procedure for Discretionary Denials (June 21, 2022) ("Guidance Memo").

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, EX1080. 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; Guidance Memo at 8-9 (median time-to-trial statistics must be considered).

The district court litigation is still in its infancy and progressing slowly. Western Digital's renewed motion to dismiss the First Amended Complaint remains pending. No trial date has been set.

To date, IP Bridge has asserted only a single claim of the '909 Patent in the litigation, EX1067 ¶125, 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). This Petition presents a compelling challenge showing all aspects of the claims existed in the prior art, including the aspects of the claims the Examiner found allegedly novel. *Supra* §§VI-VII; Guidance Memo at 4-5. *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. The Examiner never considered the combinations of prior art presented in this Petition. EX1018 at 107-

08. The Board has ample reason to conclude, under either part one or two, that *Advanced Bionics* does not apply.

The Board applies a two-part framework under *Advanced Bionics v. MED-EL Elektromedizinische Geräte*, IPR2019-01469, 2020 WL 740292, at *3 (P.T.A.B. Feb. 13, 2020) (precedential).

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*).

During prosecution, the Examiner did not have the benefit of the combinations of prior art presented in this Petition, or Patent Owner's subsequent positions on barrier height, all of which render obvious the claims, including the claimed barrier height of 0.1–0.85 eV. Bowen, Nagahama, Sunai, and Parkin were listed in an IDS, but never discussed or meaningfully addressed during prosecution. *See* EX1018 at 20-22. The Examiner did not have the benefit of Soukup's teaching of a 0.33 eV barrier height. EX1028 at Abstract. Thus, this Petition presents new information that the Examiner did not have the opportunity to consider during his initial examination. Because the grounds in this Petition were not "previously presented" to the Patent Office, trial is warranted here. *See, e.g.*, *Lifecore Fitness v. Woodway*

USA, IPR2024-00083, Paper 13 at 22 (P.T.A.B. May 17, 2024); *JUUL Labs. v. NJOY*, IPR2024-00160, 2024 WL 2697567, at *5 (P.T.A.B. May 24, 2024).

If the Board deems consideration of *Advanced Bionics* 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.

Here the Examiner's sole Office Action rejected the claims as obvious over DeBrosee and Sharma, EX1018 at 107-09, and allowed them in part after concluding the prior art did not teach a tunnel barrier height in a range of 0.1–0.85 eV, EX1018 at 170; *supra* §II.G. The Examiner erroneously believed, at Applicant's urging, that claimed barrier height of 0.1–0.85 eV was inventive. *Id.*; EX1018 at 151, 164. It wasn't. EX1028 at Abstract (Soukup: barrier height of 0.33 eV); *ChemtronicsUSA v. Flatfrog Labs.*, IPR2024-00015, 2024 WL 1719468, at *9 (P.T.A.B. Apr. 22, 2024) (ordering trial because "the Examiner did not issue a rejection based on" the Petition's prior art). The Examiner also was not informed of Patent Owner's position that the "the presence of oxygen vacancy defects indicates a tunnel barrier height as claimed." EX1064 at 19. Allowing the claims on the basis that a barrier height of 0.1–0.85 eV was not present in the prior art was material error. *See* EX1018 at 169-70.

Trial is warranted here.

X. CONCLUSION

For the reasons set forth above, Western Digital requests judgment cancelling claims 1-20 of U.S. Patent No. 11,968,909.

XI. GROUNDS FOR STANDING

Western Digital hereby certifies that the '909 Patent is available for IPR and meets the requirements of 37 C.F.R. §42.101.

XII. 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 '909 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:

Lead Counsel	Backup Counsel
Michelle E. Armond (Reg. No. 53,954) michelle.armond@armondwilson.com Postal and Hand-Delivery Address: ARMOND WILSON LLP 4685 MacArthur Court, Suite 390 Newport Beach, CA 92660 Telephone: (949) 932-0778	Douglas R. Wilson (Reg. No. 54,542) doug.wilson@armondwilson.com Postal and Hand-Delivery Address: ARMOND WILSON LLP 13785 Research Blvd., Suite 125 Austin, Texas 78750 Telephone: (512) 267-1663 Josepher Li (Reg. No. 74,998) josepher.li@armondwilson.com Monica Arnold (Reg. No. 77,262) monica.arnold@armondwilson.com Yue Han (Reg. No. 80,950) amy.han@armondwilson.com Postal and Hand-Delivery Address: ARMOND WILSON LLP 4685 MacArthur Court, Suite 390 Newport Beach, CA 92660 Telephone: (949) 932-0778

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: September 27, 2024

By: /Michelle E. Armond/
Michelle E. Armond (Reg. No. 53,954)
Douglas R. Wilson (Reg. No. 54,542)
Josepher Li (Reg. No. 74,998)
Monica Arnold (Reg. No. 77,262)
Yue Han (Reg. No. 80,950)
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. 11,968,909** exclusive of the parts exempted as provided in 37 C.F.R. §42.24, contains 13,968 words and therefore complies with the type-volume limitations of 37 C.F.R. §42.24.

ARMOND WILSON LLP

Dated: September 27, 2024

By: /Michelle E. Armond/
Michelle E. Armond (Reg. No. 53,954)
Douglas R. Wilson (Reg. No. 54,542)
Josepher Li (Reg. No. 74,998)
Monica Arnold (Reg. No. 77,262)
Yue Han (Reg. No. 80,950)
Attorneys for Western Digital Technologies, Inc.

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. 11,968,909** and **EXHIBITS 1001-1083**, are being served on September 27, 2024, via overnight mail on the patent owner at the correspondence address of record for U.S. Patent No. 11,968,909, as addressed below:

Myers Wolin, LLC
100 South Jefferson Rd., Ste. 202
Whippany, NJ 07981-1009

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

Adam W. Poff (apoff@ycst.com)
Robert M. Vrana (rvrana@ycst.com)
Alexis N. Stombaugh (astombaugh@ycst.com)
Michael A. Albert (malbert@wolfgreenfield.com)
Gerald B. Hrycyszyn (ghrycyszyn@wolfgreenfield.com)
Hunter D. Keeton (hkeeton@wolfgreenfield.com)
Aya Cieslak-Tochigi (aya.cieslak-tochigi@wolfgreenfield.com)

ARMOND WILSON LLP

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Douglas R. Wilson (Reg. No. 54,542)
Josepher Li (Reg. No. 74,998)
Monica Arnold (Reg. No. 77,262)
Yue Han (Reg. No. 80,950)
Attorneys for Western Digital Technologies, Inc.