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UNITED STATES PATENT AND TRADEMARK OFFICE

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**BEFORE THE PATENT TRIAL AND APPEAL BOARD**

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WESTERN DIGITAL TECHNOLOGIES, INC.,  
Petitioner,

v.

GODO KAISHA IP BRIDGE 1,  
Patent Owner.

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Case No. IPR2024-01386

U.S. Patent No. 9,608,198

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**PETITION FOR *INTER PARTES* REVIEW OF  
U.S. PATENT NO. 9,608,198**

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| <b>Exhibit No.</b> | <b>Description</b>                                                                                          |
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| 1001               | U.S. Patent No. 7,884,403 (“’403 Patent”)                                                                   |
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| 1005               | U.S. Patent No. 8,405,134 (“’134 Patent”)                                                                   |
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| 1007               | U.S. Patent No. 9,123,463 (“’463 Patent”)                                                                   |
| 1008               | File History for U.S. Patent No. 9,123,463                                                                  |
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| 1010               | File History for U.S. Patent No. 9,608,198                                                                  |
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| 1013               | U.S. Patent No. 10,680,167 (“’167 Patent”)                                                                  |
| 1014               | File History for U.S. Patent No. 10,680,167                                                                 |
| 1015               | U.S. Patent No. 11,737,372 (“’372 Patent”)                                                                  |
| 1016               | File History for U.S. Patent No. 11,737,372                                                                 |
| 1017               | U.S. Patent No. 11,968,909 (“’909 Patent”)                                                                  |
| 1018               | File History for U.S. Patent No. 11,968,909                                                                 |
| 1019               | Patent Family Tree                                                                                          |
| 1020               | Japanese Patent No. JP2004071186                                                                            |
| 1021               | English Translation of Japanese Patent No. JP2004071186, from ’372 Patent File History (EX1015)             |
| 1022               | Japanese Patent Application No. JP2004313350                                                                |
| 1023               | Certified English Translation (with Translator Declaration) of Japanese Patent Application No. JP2004313350 |
| 1024               | Declaration of Jeffrey Bokor, Ph.D.                                                                         |

| Exhibit No. | Description                                                                                                                                                                                                                  |
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| 1025        | CV of Jeffrey Bokor, Ph.D.                                                                                                                                                                                                   |
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| 1028        | Soukup et al., <i>Voltage-Current Characteristics for Electrical Conduction Through Thin MgO Films</i> , 41 J. Appl. Phys. 3229-3236 (1970) (“Soukup”)                                                                       |
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| 1062        | U.S. Patent No. 7,270,896 (“Parkin”)                                                                                                                                                   |
| 1063        | Complaint, <i>Godo Kaisha IP Bridge 1 v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024) (without exhibits)                                         |
| 1064        | Claim Chart for ’403 Patent, Exhibit D to Complaint, <i>Godo Kaisha IP Bridge 1 v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024)                  |

Western Digital v. Godo Kaisha IP Bridge  
IPR Petition – U.S. Patent No. 9,608,198

| <b>Exhibit No.</b> | <b>Description</b>                                                                                                                                                                          |
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| 1065               | Claim Chart for '263 Patent, Exhibit E to Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024)                       |
| 1066               | Claim Chart for '372 Patent, Exhibit F to Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024)                       |
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| 1068               | Amended Claim Chart for '403 Patent, Exhibit AA to First Amended Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024) |
| 1069               | Amended Claim Chart for '263 Patent, Exhibit BB to First Amended Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024) |
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| 1071               | Claim Chart for '909 Patent, Exhibit DD to First Amended Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024)         |
| 1072               | Claim Chart for '138 Patent, Exhibit EE to First Amended Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024)         |
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| 1075               | Claim Chart for '167 Patent, Exhibit HH to First Amended Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024)         |

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| Exhibit No. | Description                                                                                                                                                                                                                                                                                                                  |
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| 1078        | U.S. District Courts – Combined Civil and Criminal Federal Court Management Statistics (Dec. 31, 2023), <a href="https://www.uscourts.gov/statistics-reports/federal-court-management-statistics-december-2023">https://www.uscourts.gov/statistics-reports/federal-court-management-statistics-december-2023</a> (excerpts) |
| 1079        | Microsoft Computer Dictionary (5th ed. 2002) (excerpts)                                                                                                                                                                                                                                                                      |

## LIST OF CHALLENGED CLAIMS

1[pre] A tunnel barrier layer disposed between a first ferromagnetic material layer and a second ferromagnetic material layer that are disposed over a substrate,

1[a] wherein the tunnel barrier layer comprises a poly-crystalline magnesium oxide layer in which a (001) crystal plane is preferentially oriented,

1[b] wherein the first ferromagnetic material layer is composed of an Fe—Co alloy of BCC which alloy comprises Fe, Co, and B,

1[c] wherein the first ferromagnetic material layer is located between the tunnel barrier layer and the substrate.

2. The tunnel barrier layer according to claim 1, wherein a barrier height of the tunnel barrier layer is in a range of 0.2 to 0.5 eV.

3[pre] The tunnel barrier layer according to claim 2,

3[a] wherein the barrier height  $p$  of the tunnel barrier layer is obtained by fitting J-V characteristics of a tunnel barrier junction structure to an equation (1):

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

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

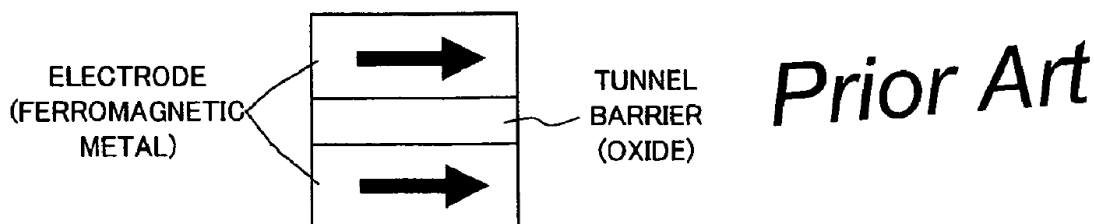
4. The tunnel barrier layer according to claim 1, wherein the second ferromagnetic material layer is composed of an alloy comprising Fe and Co, and wherein the second ferromagnetic material layer is located above the tunnel barrier layer.

5. The tunnel barrier layer according to claim 1, wherein the second ferromagnetic material layer is composed of an alloy comprising Fe, Co, and B, and wherein the second ferromagnetic material layer is located above the tunnel barrier layer.

6. The tunnel barrier layer according to claim 1, wherein the tunnel barrier layer is disposed on the first ferromagnetic material layer.

## 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 '198 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. EX1009 at 1:38-40. The '198 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:

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

EX1031 at Abstract, 1797 (Eq. (25)).

During prosecution of a parent patent to the ’198 Patent, U.S. Patent No. 7,884,403, the Examiner believed that the claimed barrier height of 0.2 to 0.5 eV was inventive, EX1002 at 235, and applicant never informed him otherwise, *see* EX1002 at 254-60; EX1028 at Abstract (Soukup: barrier height of 0.33 eV). Claims 2-3 of the ’198 Patent require the same barrier height of 0.2 to 0.5 eV, yet the applicant never corrected the Examiner during prosecution of the ’198 Patent either. EX1009 at 10:18-35; *see generally* EX1010. Nor was the Examiner informed of Patent Owner’s position that the “the presence of oxygen vacancy defects indicates a tunnel barrier height as claimed.” *E.g.*, EX1064 at 19 (’403 Patent infringement allegations); EX1010. Claims 3 of the ’198 Patent merely recites Simmons’ famous formula, EX1009 at 10:20-34, and that is not inventive either, EX1031.

This Petition presents two grounds showing all claims of the ’198 Patent were obvious:

- Bowen (Ground 1): A 2001 paper by Bowen et al. in *Applied Physics Letters* (EX1026) builds high-quality FeCo/MgO/Fe MTJs to achieve a high TMR. Bowen observed the presence of defects in the MgO barrier led to increased tunneling, suggesting a low barrier height, previously observed by Soukup. Sunai taught the advantages of using CoFeB electrodes in MgO MTJs for MRAM.
- Nagahama (Ground 2): A 2002 European patent application publication also naming Dr. Yuasa and collaborators (EX1027) disclosed nearly every aspect of an MgO MTJ he later sought to claim in the '198 Patent, including a TMR of more than 90%, rendering the claims obvious over Nagahama coupled with Soukup's observations about the barrier height.

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 '198 Patent challenged here. EX1063 ¶¶3, 10; EX1067 (same). In March, IP Bridge filed suit in the District of Delaware against Western Digital, asserting that essentially its entire hard drive product line infringed U.S.

Patent No. 7,884,403 and two related patents. *Id.* ¶¶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 (reproducing EX1009, Fig. 1(B)).

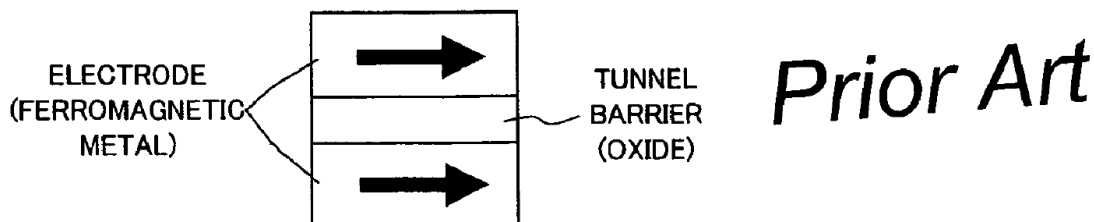


Almost nothing has happened in the Delaware litigation. EX1077. Confronted with a motion to dismiss its original complaint, IP Bridge filed a First Amended Complaint asserting six more related patents, including the '198 Patent. EX1067 ¶2; EX1019. Western Digital filed another motion to dismiss and also moved to transfer the case to California. As of the filing of this Petition, both motions remain pending. EX1077.

## **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

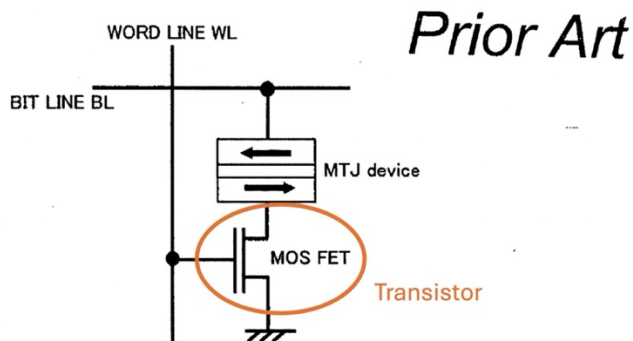
conventionally is a magnetic tunnel junction (MTJ) with two ferromagnetic layers separated by a thin oxide layer:



EX1009 at Fig. 8(A); *see also id.* at Fig. 8(B), 1:42-67; EX1027 at Fig. 3; EX1030 at Fig. 1; EX1024 ¶¶32-33.

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

FIG. 9 (B)



EX1009 at Fig. 9(B) (annotated); EX1030 ¶¶37-40, Figs. 4-5; EX1039 at 2816, 2818 (MRAM cell “transistors provide bit selection for reading individual bits.”); EX1049 at Abstract (explaining that “[t]he simplest architecture of MRAM cell is a

combination of MTJ... as a data storage part and MOS transistor as a data selection part”), Fig. 2 (showing “MRAM cell with a MTJ and a transistor”); 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.*; EX1009 at 1:51-67.

As shown at right, if the MTJ has

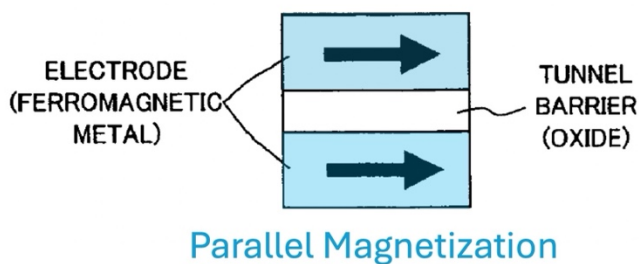
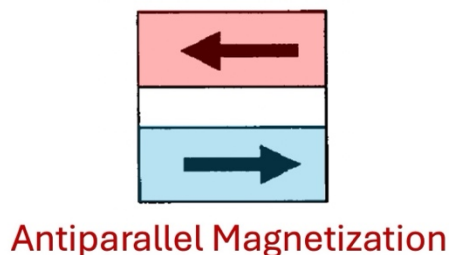
low resistance, this indicates the

electrodes have **parallel**

**magnetization**; high resistance

indicates **antiparallel**

**magnetization**. EX1009 at 1:51-



62, Figs. 8(A)-8(B) (excerpted, annotated). EX1024 ¶¶34-35.

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 (“TMR value is also the most important parameter...”). 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, the 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; EX1009 at 4:62-5:3; EX1024 ¶¶36-39. 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.”); EX1009 at 2:38-55; EX1024 ¶¶39-44. 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 ¶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 ¶¶40-44.

Two decades after Jullière, Miyazaki and Moodera separately measured TMR above 10%, demonstrating the tunneling effect at room temperature. EX1034 at Abstract (reporting TMR of “18% at 300 K”); EX1035 at Abstract (TMR of 11.8% at 295 K). “Since 1995, extensive experimental effort has been made on MTJs with

amorphous AlO barriers and ferromagnetic electrode[s]....” EX1057 at 43. The patent itself acknowledges that then-current MTJ devices exhibited TMRs of “approximately 70%.” EX1009 at 5:19-22.

In 2001, separate research teams led by Butler (EX1044) and Mathon (EX1046) 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). Butler’s and Mathon’s publications spurred a scientific gold rush, with researchers publishing an explosion of research into MgO MTJs. As one researcher put it: “TMR[] in magnetic tunnel junctions (MTJs) is widely studied nowadays due to the large-scale potential applications of MTJs” in MRAM and data storage. EX1052 at 4507.

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

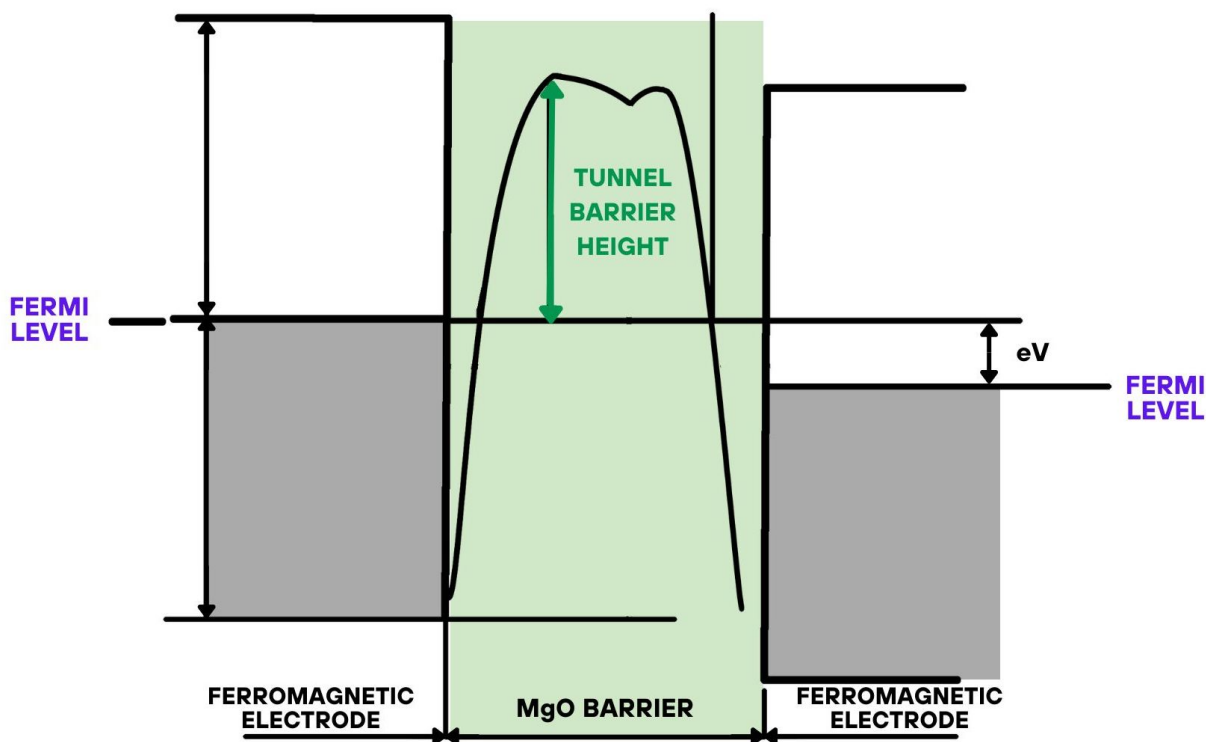
MTJ behavior is explained by quantum mechanics. Current typically flows through conductors and is inhibited by insulators. EX1024 ¶45. But in the 1930s, researchers discovered that current (electrons) could flow between two electrodes separated by a very thin insulating layer (or barrier). EX1031 at 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 ¶46-47. 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 ¶46-47. 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 (“When  $V$  is zero, a state of dynamic equilibrium can be

considered to exist—that is, a current ... [is] flowing in either direction.”). 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; EX1009 at 3:56-62; EX1024 ¶48. Simmons’ 1963 paper provided a widely used formula for calculating the tunnel barrier height.<sup>1</sup> EX1031 at 1797 (Eq. (25)); EX1026 at 1656; EX1035 at 3274; EX1009 at 7:27-33; 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

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<sup>1</sup> Simmons’ formula for the low-voltage range is:

$$J = [3(2m\phi)^{\frac{1}{2}}/2s](e/h)^2 V \times \exp[-(4\pi s/h)(2m\phi_0)^{\frac{1}{2}}].$$

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)).

(emphasis in original); *see also* EX1050 at 2427 (Yuasa: “The TMR effect is also known to be sensitive to the barrier/electrode interface” and “barrier materials.”). To improve tunneling and TMR, researchers studied different materials for the ferromagnetic electrodes and barrier layer. *E.g.*, EX1055 at 2269; EX1024 ¶50.

### **1. Ferromagnetic Materials**

Well-known ferromagnetic materials such as Fe, Ni, Co, and their alloys typically have crystalline structures. EX1030 ¶33 (“ferromagnetic materials” include “Fe, Co, Ni, and alloys containing them”); EX1024 ¶¶54-55. Alignment between the crystal of the electrodes and the barrier layer facilitates 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<sub>50</sub>Co<sub>50</sub> electrode layers); EX1052 at 4507 (using Fe and Co layers to try to achieve the calculated high TMRs); EX1024 ¶¶57-58.

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 (ferromagnetic layer “comprised of a CoFeB alloy... exhibits a larger TMR ratio”). 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. 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 ¶¶59-62.

## **2. Barrier Layers**

Initially, there was significant interest in aluminum oxide ( $\text{Al}_2\text{O}_3$ ) barrier layers. EX1024 ¶¶63-65; EX1052 at 4507; EX1044 at 1. But  $\text{Al}_2\text{O}_3$  was amorphous and lacked an ordered crystalline lattice structure or symmetry with the electrodes. EX1044 at 1; EX1045 at 1; EX1009 at 5:26-34 (contrasting crystalline MgO and amorphous  $\text{Al}_2\text{O}_3$  barriers). This “lattice disorder” resulted in incoherent tunneling with the electrons prone to scattering. EX1045 at 1. By the early 2000s, MTJs with  $\text{Al}_2\text{O}_3$  barriers conventionally had TMRs “at approximately 70%.” EX1009 at 2:49-51, 5:19-22; EX1063 ¶18; EX1055 at 2270 (“TMR value of 70.4%”).

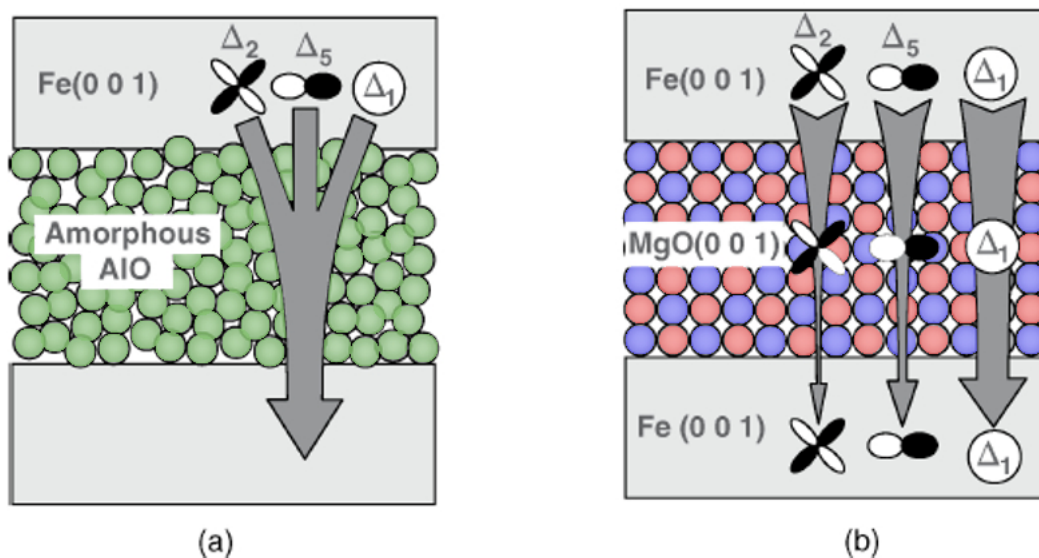
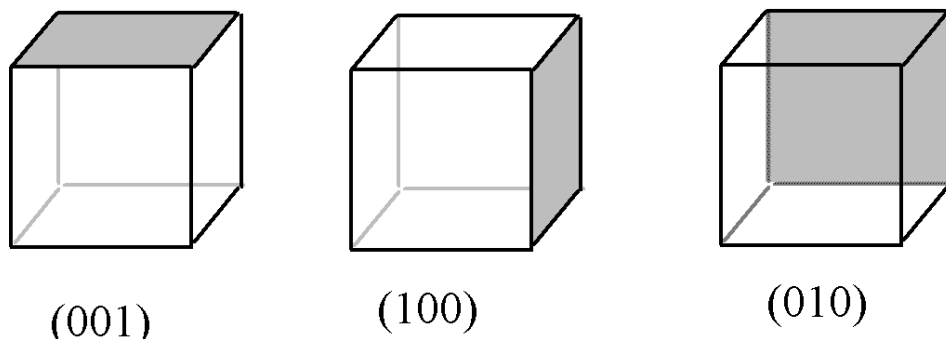


Figure 2.19 Schematic of electron tunneling through (a) an amorphous AlO barrier and (b) a crystalline MgO(0 0 1) barrier.

EX1057 at 44, Fig. 2.19 (annotated).

Thin film magnesium oxide (MgO) barriers had been studied for years. EX1028 at 3229; EX1038 at Abstract. 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. EX1009 at 4:39-40; EX1040 at 2839. Its symmetric structure results in the (001), (100), and (010) crystalline planes being the same:



EX1009 at 4:39-41 (“[B]ecause MgO has a cubic crystal structure (NaCl structure), the (001) plane, the (100) plane, and the (010) plane are all equivalent.”); EX1024 ¶¶51-53, 67.

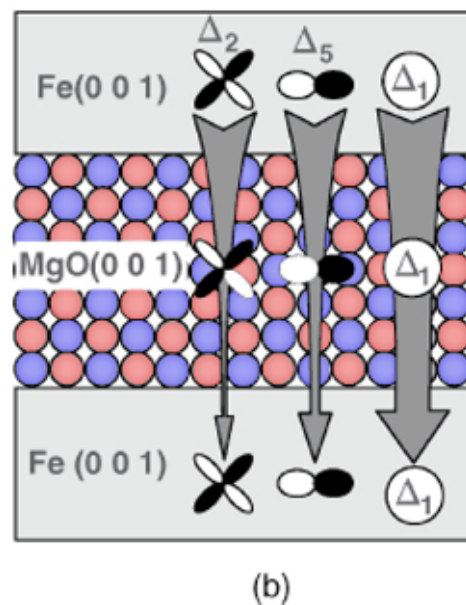
In 2001, Butler and Mathon separately “calculated [the] optimistic TMR ratio is in excess of 1000% for an MgO barrier.” EX1046 at Abstract; *see also* EX1044 at Fig. 16; EX1024 ¶¶68-69. Butler pointed out that tunneling across an MgO barrier was facilitated by the “symmetry” between the electrodes and barrier material, which “are crucial to determining the tunneling conductance.” EX1044 at 1. Mathon also cited the tight symmetry between the crystal structures of a thin MgO barrier and Fe electrodes in an MTJ, with “only a small lattice mismatch of about 3.5%.” 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; EX1044 at 1 (different tunneling mechanisms facilitated tunneling in the parallel majority channel compared to the antiparallel minority channel); EX1024 ¶68.

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. EX1024 ¶73. A metal oxide's properties “are directly or indirectly connected to the presence of defects and in particular of point defects.” EX1042 at 161. “Oxygen vacancies are naturally present in every oxide....” EX1042 at 162; *see also id.* (“[P]erfect, defect free, oxides are simply an idealization and do not exist in nature.”).

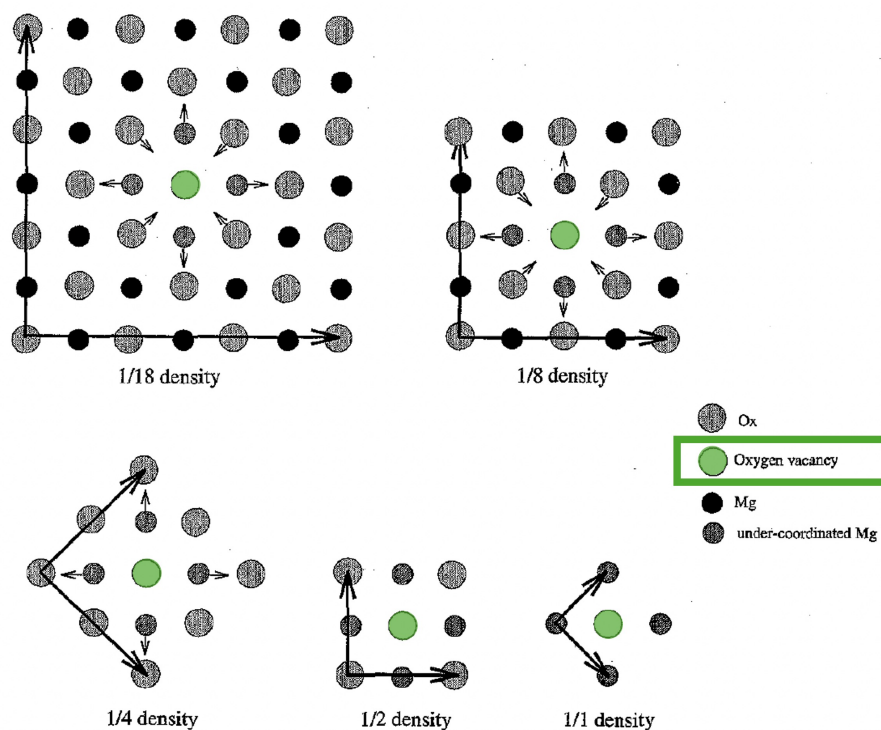
The idealized MgO structure is stoichiometric with a 1:1 ratio of Mg (blue) and O atoms (red) in its cubic crystalline structure. EX1042 at 162; EX1009 at 6:32-34; EX1057 at 44, Fig. 2.19 (excerpted, annotated); EX1024 ¶74. One way to quantify the level of oxygen vacancies in MgO crystal is by describing a sub-



stoichiometric composition of  $\text{MgO}_x$ , where  $x < 1$  ( $x = 1$  in an idealized, perfectly stoichiometric crystal). EX1041 at 132 (“understoichiometric  $\text{MgO}_x$  ( $x < 1$ )”);

EX1009 at 7:6-7 (“[T]here is the possibility that there are oxygen vacancy defects such as  $\text{MgO}_x$  ( $0.9 < x < 1$ ).”), 7:22-24; EX1002 (’403 File History) at 168 (Applicant: “ $\text{MgO}_x$  ( $0 < x < 1$ )” and “ $x$  is  $0 < x < 1$ . (Namely, if this is represented as ‘MgO crystals,’ the crystals have oxygen vacancy defects.).”); EX1024 ¶75.

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



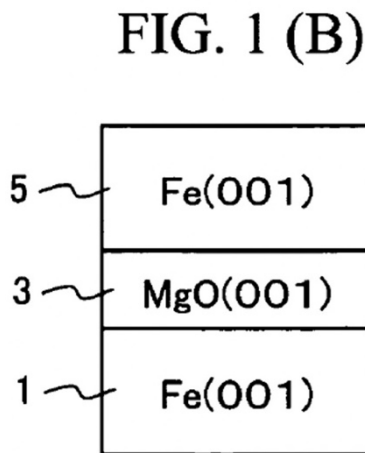
EX1037 at 3, Fig. 1 (annotated); *see also* EX1009 at 6:32-34 (contrasting using “a source with oxygen vacancy defects” instead of “the MgO of the stoichiometric composition (the ratio of Mg to O is 1:1)”); EX1024 ¶76.

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 ¶¶77-81. 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 (“The exact composition of the MgO layer may differ from the stoichiometric composition.”); EX1024 ¶82.

#### F. '198 Patent Family

The '198 Patent teaches an MTJ with a single-crystalline or polycrystalline MgO barrier layer sandwiched between two Fe electrodes. *Id.* at Fig. 1(B) (excerpted at right), 1:45-49, 5:39-45; EX1024 ¶¶83-86.

The patent purports to claim an MTJ device that is disposed over a substrate, wherein the lower, or first, electrode comprises “an Fe-Co alloy of BCC which alloy comprises Fe, Co, and B,” *e.g. id.* at 10:6-17 (Claim 1); *id.*, Abstract, and the upper, or second, electrode is simply ferromagnetic, *id.* at 10:36-45 (Claims 4 and 5); *id.*, Abstract. Claims 2 and 3 require a tunnel barrier height “in a range of



0.2 to 0.5 eV.” *Id.* at 10:18-20. Claim 3 further requires that the barrier height be “obtained by fitting J-V characteristics of a tunnel barrier junction structure to” Simmons’ formula where the bias voltage is set to “100 mV or smaller,” the “effective thickness of the tunnel barrier layer” is “approximately equivalent to ( $t_{\text{MgO}} - 0.5\text{nm}$ ), and  $t_{\text{MgO}}$  is an actual thickness of the tunnel barrier layer.” *Id.* at 10:21-35.

### **G. The Prosecution Of The '198 Patent**

The '198 Patent is ultimately a continuation of U.S. Patent No. 7,884,403 and claims priority to two Japanese Patents, JP 2004-071186 and 2004-313350. EX1009 at 1, [63], [30], 1:7-14. The October 28, 2004 application included a new Figure 11 and related disclosure of a CoFeB electrode not included in the earlier, March 12, 2004 application. *Compare* EX1020-EX1021, *with* EX1022-EX1023.

In the first office action, the Examiner rejected all three original claims under 35 U.S.C. §112, second paragraph, as (1) being indefinite, and (2) “omitting essential steps” of “a first and second ferromagnetic material layers on a poly-crystalline magnesium oxide layer,” EX1010 at 165-66, and under 35 U.S.C. §103 as obvious over U.S. Patent Application Publication No. 2008/0062581 (Parkin) in view of U.S. Patent No. 5,514,484 (Nashimoto). *Id.* at 166-67. The Examiner found that Parkin disclosed “a substrate 111,” “a first amorphous ferromagnetic layer 115 made of CoFeB alloy of a BCC structure,” “[a]n amorphous second ferromagnetic material

layer 175 comprising a CoFeB alloy,” “[a] tunnel barrier layer 120 made of MgO located between the first and second ferromagnetic material layers,” and Nashimoto disclosed “that it is well known in the semiconductor industry that a MgO barrier layer can have a (100) or (001) crystal plane.” *Id.* at 167. The Examiner also issued a non-statutory double patenting rejection based on the three claims not being patentably distinct over the ’403 Patent’s claim 1 because all the claims required a “tunnel barrier layer made of magnesium oxide layer and a ferromagnetic material layer made of FeCoB.” *Id.* at 169.

In response to the first office action, the applicant amended the existing claims. *Id.* at 195-204. The applicant argued that “neither Parkin nor Nashimoto teaches or suggests that ‘the ferromagnetic material layer is composed of an Fe-Co alloy of BCC which alloy **comprises Fe, Co, and B,**’ as required by independent claim 1.” *Id.* at 202 (emphasis in original).

The Examiner then issued a second office action with another double patenting rejection and also rejected claim 6 as being unpatentable under 35 U.S.C. §112 for being “vague and indefinite.” *Id.* at 209-215.

The applicant again amended the claims and filed a terminal disclaimer to overcome the rejection. *Id.* at 222-27. The Examiner then allowed the claims. *Id.* at 237. After allowance, the applicant amended the claims once again, changing claim 3 to read “tunnel barrier layer” instead of just “tunnel barrier.” *Id.* at 251-55.

#### **H. Soukup (EX1028)**

Inspired by Simmons, University of Minnesota researchers R.J. Soukup and D.E. Speliotis published their results on MgO thin films in a 1970 paper. Soukup prepared samples of “Au-MgO-Au thin-film” devices. EX1028 at Abstract, 3229-30; EX1024 ¶¶96. He observed a tunnel barrier height of 0.33 eV for their MgO barrier. EX1028 at Abstract, 3232, Table I; EX1024 ¶¶97. Soukup is not cited on the face of the ’198 Patent. *See* EX1009 at 3-4.

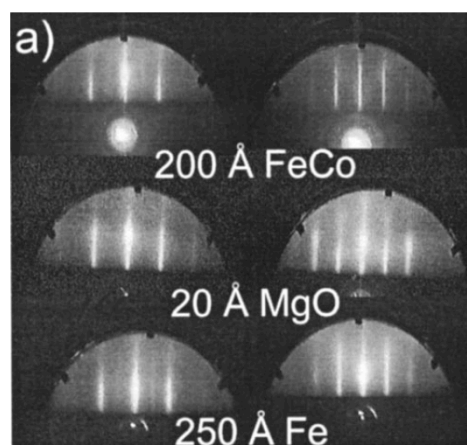
Soukup also explained the relationship between oxygen vacancy defects and barrier height of the MgO barrier. EX1028 at 3232 (Soukup performed experiments “[i]n order to determine the effect of nonstoichiometry on the device characteristics.”); EX1024 ¶¶98. He found results showing “that admitting oxygen gas during deposition of the MgO film increases the stoichiometry of the film as seen by an increased barrier height.” EX1028 at 3232. Because more stoichiometric MgO films have fewer oxygen vacancy defects, Soukup showed that increasing stoichiometry (reducing oxygen vacancy defects) increased the barrier height. EX1028 at 3232; EX1024 ¶¶98; *supra* §II.E. In other words, higher oxygen vacancy defects lowered the barrier height. *See id.*

#### **I. Bowen (EX1026)**

Also following Simmons’ trail, in 2001 a consortium of European researchers led by M. Bowen published their findings on “Fe/MgO/FeCo(001)” MTJs in *Applied*

*Physics Letters*. EX1026 at 1655, 1657 n.13 (citing Simmons (1963)); EX1024 ¶¶90-91. Bowen is listed on the face of the '198 Patent. EX1009 at 3.

Using Butler's and Mathon's calculations showing giant TMR for MgO thin films as a starting point, Bowen grew "FeCo/MgO/Fe epitaxial structures" (shown at right) with "increasingly thin MgO layers" to study their TMR. EX1026 at 1655, 1657 nn.5-6, Fig. 1 (excerpted). Using "good crystal quality MgO films with sharp interfaces," Bowen's tunneling experiments resulted in TMR measurements of 60%. *Id.* at Abstract, 1655-56. Bowen also noted the likely "presence of stoichiometric and/or thickness inhomogeneities" in the MgO barrier. *Id.* at 1656.



Bowen stated his intent "to confirm the predicted relative increase of the TMR" by Butler in "future experiments." EX1026 at 1657.

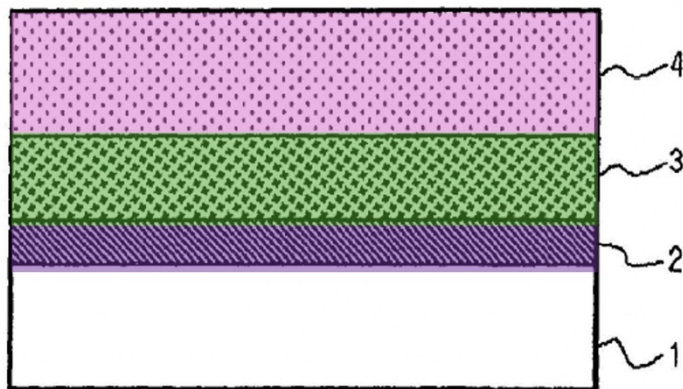
#### **J. Nagahama (EX1027)**

Meanwhile, named inventor Dr. Yuasa and his colleagues Taro Nagahama and Yoshishige Suzuki were also working at the National Institute of Advanced Industrial Science and Technology in Tsukuba, Japan. EX1027 at 1. In a 2002 patent application by Nagahama et al., the researchers disclosed an MTJ with an MgO

barrier. EX1027 ¶73; EX1024 ¶92. The '198 Patent lists Nagahama. *See* EX1009 at 2.

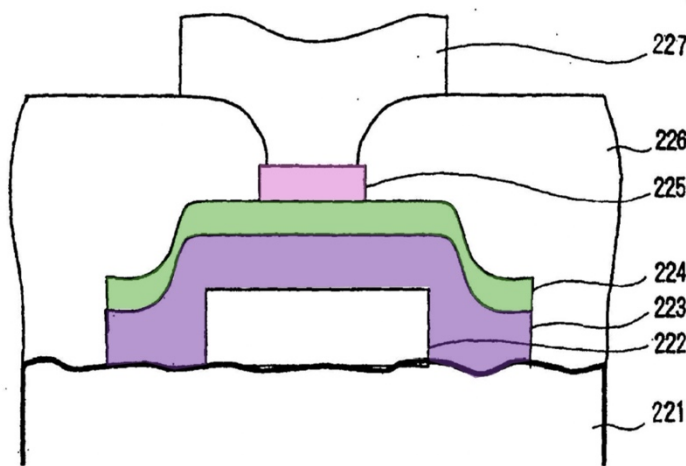
As shown at right,  
Nagahama generally disclosed  
an MTJ structure with a  
ferromagnetic electrode 4  
[pink], insulating layer 3  
[green], and another ultrathin  
ferromagnetic layer 2 [purple]

FIG. 3



on a substrate underlayer 1 [white]. EX1027 at Abstract, Fig. 3 (excerpted, annotated); EX1024 ¶93.

FIG. 17



Nagahama also specified a  
polycrystalline MgO thin-film  
MTJ (at left) with “a (001)-  
highly-oriented lower  
ferromagnetic electrode layer  
[purple], a (001)-highly-oriented  
MgO barrier layer [green], and a  
(001)-highly-oriented upper

ferromagnetic electrode layer [pink].” EX1027 ¶¶73, 75-76, Fig. 17 (annotated);

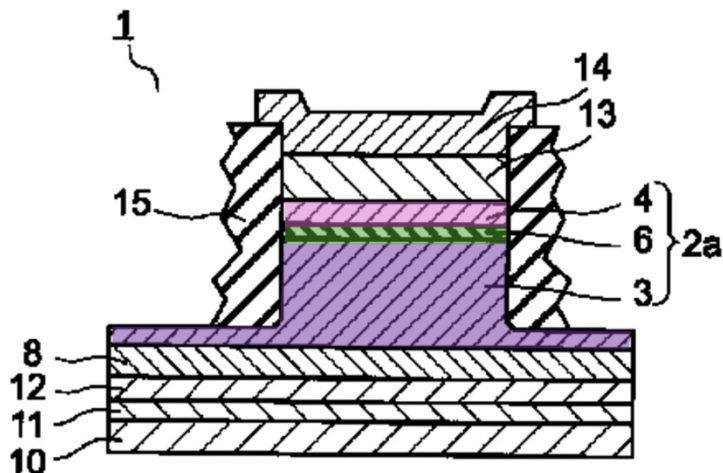
EX1024 ¶¶94. The ferromagnetic electrodes used a bcc lattice. *Id.* ¶18 (item [20]). Nagahama taught that its MgO MTJ obtained better results than Bowen (EX1026), EX1027 ¶14, touting “a larger tunnel magnetoresistive effect of more than 90%,” *id.* ¶74; EX1024 ¶94. The application described the “Industrial Applicability” of their invention to “a magnetic sensor of a pickup head of a hard disk drive or a ferromagnetic random access memory.” *Id.* ¶82; EX1024 ¶95.

**K. Sunai (EX1029/EX1030)**

Japanese Patent Application Publication No. JP2002204004A to Sunai et al. was filed by Toshiba in 2000. EX1029 at 1, [22]. A certified English translation of Sunai is submitted as EX1030. *See* 37 C.F.R. §42.63(b). Sunai described an MTJ for a “magnetic memory” device (including MRAM) that was capable of “maintain[ing] a sufficiently high magnetoresistance ratio.” EX1030 at Abstract, ¶4; EX1024 ¶¶99-101. Sunai is listed on the face of the ’198 Patent. *See* EX1009 at 2.

Sunai taught a conventional 3-layer MTJ (shown at right) with “a first ferromagnetic layer 3” [purple], “a second ferromagnetic layer 4” [pink], and “a first tunnel barrier layer 6 [green]” between the ferromagnetic layers. EX1030 at

[Figure 1]

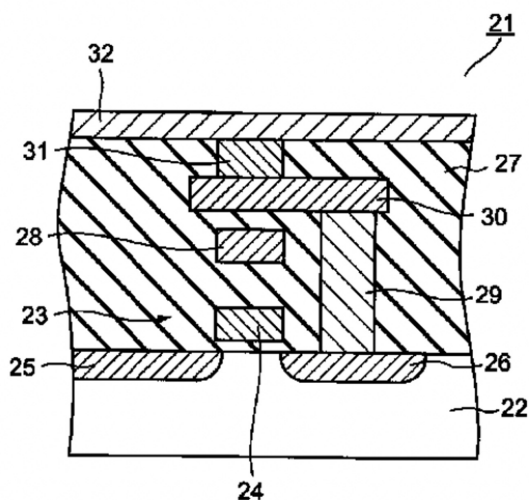


Abstract, Fig. 1 (annotated), ¶1; EX1024 ¶102.

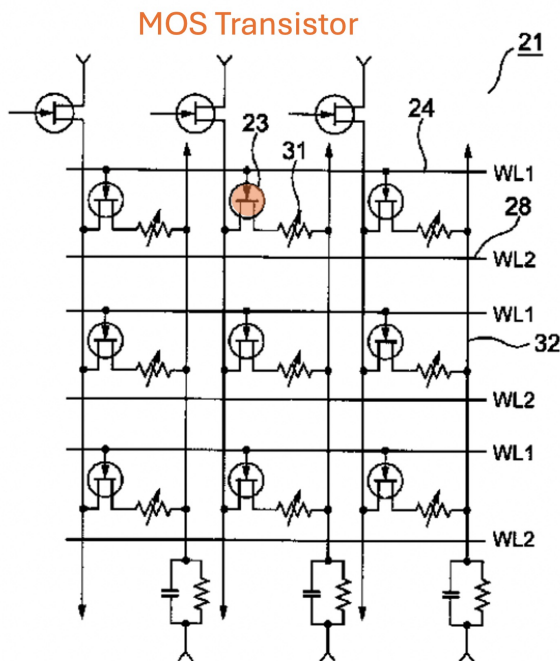
It taught that its MTJ included a CoFeB ferromagnetic layer. EX1030 at Abstract, ¶¶11, 24 (“[T]he composition of the ferromagnetic layer 4 is represented by the general formula  $(\text{CoFe})_{100-x}\text{Y}_x$ ” where “Y is at least one element selected from the group consisting of B” and other elements.); EX1024 ¶103.

Sunai’s MTJ was a memory element in an MRAM:

[Figure 4]



[Figure 5]



EX1030 ¶¶37-40, Figs. 4-5 (Fig. 5 annotated); EX1024 ¶104. Figures 4 and 5 show a “cross-sectional view” of an MRAM and the “equivalent circuit diagram of the MRAM,” respectively. EX1030 ¶38. A transistor (**orange**) and MTJ (Sunai’s “TMR 31”) together form the memory cell in the array. EX1030 ¶42; EX1024 ¶104.

### 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 1-6 of the '198 Patent based on the following grounds.

**Ground 1:** Claims 1 and 4-6 are obvious over Bowen in view of Sunai. Claims 2 and 3 are obvious over Bowen in view of Sunai and Soukup.

**Ground 2:** Claims 1 and 4-6 are obvious over Nagahama in view of Sunai. Claims 2 and 3 are obvious over Nagahama in view of Sunai and Soukup.

**B. The Prior Art**

**1. March 10, 2004 Critical Date For The '198 Patent**

The '198 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 (“[T]he effective filing date of the claimed invention is the actual filing date of the U.S. application” and “the actual U.S. filing date of an application that entered the

national stage under 35 U.S.C. 371 is the international filing date.”); *id.* (“The effective filing date for claims subject to pre-AIA 35 U.S.C. 102 is not the filing date of the foreign priority document....”).

“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 ’198 Patent claims priority to the ’403 Patent PCT application, PCT/JP2005/04720 filed on March 10, 2005. EX1009 at 1, [63]. 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 ’198 Patent is March 10, 2004, *Group One v. Hallmark Cards*, 254 F.3d 1041, 1044-45 (Fed. Cir. 2001) (“[T]he United States filing date, for §102(b) purposes, of a patent application filed under the PCT in which the United States is designated, is the date of the PCT application—in this case, November 12, 1992. Thus, the ‘critical date’ is November 12, 1991.”).

## **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 ’198 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 '198 Patent. The '198 Patent claims all require a ferromagnetic layer comprising "Fe, Co, and B." EX1009 at 10:13-15. There is no disclosure of a CoFeB layer in the March 12, 2004 Japanese application (JP 2004-071186) to which the '198 Patent claims priority. EX1009 at [30]. The earliest disclosure of CoFeB is the October 28, 2004 Japanese application (JP 2004-313350) to which the '198 Patent claims priority, rendering Parkin prior art under Sections 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 ¶¶24-25.

## **VI. GROUND 1: CLAIMS 1-6 ARE OBVIOUS OVER BOWEN IN VIEW OF SUNAI (AND SOUKUP)**

### **A. Claim 1**

Claim 1 would have been obvious over Bowen in view of Sunai.

- 1. Claim 1[preamble]: “A tunnel barrier layer disposed between a first ferromagnetic material layer and a second ferromagnetic material layer that are disposed over a substrate,”**

To the extent limiting, Bowen disclosed or suggested a tunnel barrier layer disposed between two ferromagnetic material layers that are all together disposed over a substrate as claimed. EX1026 at Abstract, 1655 (discussing Fe/MgO/FeCo epitaxial structure), Fig. 1; EX1024 ¶¶108-09; *see infra* §§VI.A.2-VI.A.4.

The “ferromagnetic material layer” refers to an “electrode made of a ferromagnetic metal.” EX1009 at 1:45-49, Fig. 8(a); EX1024 ¶110; *supra* §II.B.

The “tunnel barrier layer” refers to “an oxide [that] is sandwiched between a first and a second electrode....” *Id.* “First” refers to the “lower” ferromagnetic electrode that is closest to the substrate, and “second” refers to the “upper” ferromagnetic electrode. EX1009 at Abstract; EX1024 ¶110.

Bowen disclosed that its “Fe(200 Å)” of its “Fe(200 Å)/MgO(20 Å)/FeCo(250 Å) trilayer” was the “first ferromagnetic layer” and its “FeCo(250 Å)” was the “second ferromagnetic layer.” EX1026 at 1655-56 (describing growing its “Fe bottom electrode” and “FeCo top electrode”). Bowen disclosed growing its “Fe(200 Å)/MgO(20 Å)/FeCo(250 Å) trilayer” structures on “GaAs” substrates with an MgO “interdiffusion barrier” in between to “prevent[] the incorporation of As from the substrate into the Fe bottom electrode.” EX1026 at 1655-56. One of skill in the art would understand Bowen’s disclosure meant that its MTJ was disposed first over the substrate, which included both the GaAs layer and the MgO interdiffusion barrier layer. The MTJ included the lower, or first, electrode, the MgO tunnel barrier, and the FeCo upper or second electrode, so that together, its Fe/Mg/FeCo MTJ was on top of, or “disposed over,” the GaAs/MgO substrate. EX1026 at 1656, Fig. 1; EX1024 ¶¶111-15.

2. **Claim 1[a]: “wherein the tunnel barrier layer comprises a poly-crystalline magnesium oxide layer in which a (001) crystal plane is preferentially oriented,”**

Bowen alone and/or in view of Sunai taught or suggested this limitation.

Bowen described a single-crystal MgO(001) tunnel barrier layer:

A test of these models can be performed on *single-crystal* epitaxially grown structures... [and] we present experimental results showing large TMR values in Fe(001)/**MgO(001)**/FeCo(001) epitaxial tunnel junctions.

EX1026 at 1655<sup>2</sup>; *id.* at Abstract (“We present tunneling experiments on Fe(001)/**MgO**(20 Å)/FeCo(001) *single-crystal* epitaxial junctions of high quality...”); EX1024 ¶117. However, Bowen explained that Moodera’s 1996 study used “polycrystalline MgO” to obtain the same barrier height of 0.9 eV Bowen obtained. EX1026 at 1656 (citing EX1038); *KSR v. Teleflex*, 550 U.S. 398, 416 (2007) (“The combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results.”). Like Bowen, one of skill would have understood that substituting polycrystalline MgO for single-crystal MgO would yield desirable and entirely predictable results, such as improved flexibility in substrate selection. EX1026 at 1656; EX1024 ¶¶118-20.

Additionally, as Bowen disclosed, a skilled artisan readily understood that

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<sup>2</sup> All emphasis added unless otherwise noted.

polycrystalline MgO(001) could be used in place of single-crystal MgO(001) with similar results. EX1024 ¶¶118-20; EX1062 at 9:58-10:2 (describing use of polycrystalline MgO methods to prepare “epitaxial single crystalline film structures”), 13:3-10 (describing high TMR derived from crystalline ferromagnetic electrodes above and below “the (100) textured MgO tunnel barrier”), 14:35-41 (describing preferred MgO layers, which are (100) oriented [(001) oriented] bcc), 15:15-18 (“[T]he TMR will be increased to the extent that the film structure is textured [*i.e.*, poly-crystalline].”), 18:49-51 (“highly textured (100) MgO tunnel barriers”). MgO(100) is the same thing as MgO(001) because the cubic structure is symmetrical. EX1024 at ¶119.

**3. Claim 1[b]: “wherein the first ferromagnetic material layer is composed of an Fe—Co alloy of BCC which alloy comprises Fe, Co, and B,”**

Claim 1[b] does not specify any molecular composition or stoichiometry of the claimed alloy of “Fe, Co, and B,” and thus any bcc CoFeB alloy satisfies it. EX1009 at 10:13-15; EX1024 ¶122.

Bowen in view of Sunai disclosed or suggested a first Fe ferromagnetic material layer as claimed. Bowen taught: “FeCo/MgO/Fe epitaxial structures were grown on GaAs(001) in a combined sputtering/laser ablation system....” EX1026 at 1655; *id.* at Abstract, Fig. 1; EX1024 ¶121.

Iron (Fe) was a well-known ferromagnetic material. EX1030 ¶33 (“ferromagnetic materials” include “Fe, Co, Ni, and alloys containing them”); EX1026 at 1655; EX1024 ¶124.

Bowen taught that the Fe layer is on a first side of the MgO barrier layer. EX1026 at 1655 (“Fe bottom electrode”); *id.* at Abstract, Fig. 1, 1656; EX1024 ¶¶113, 121. Bowen explained that the “Fe<sub>50</sub>Co<sub>50</sub> and *Fe layers are bcc structured* with sharp diffraction lines for both azimuths.” EX1026 at 1655, Fig. 1; EX1024 ¶123.

MTJs with ferromagnetic metal layers were also conventional. EX1009 at 1:45-49 (Description of Related Art); *id.* at Figs. 8(A)-8(B); EX1045 at 1 (describing “Fe/MgO/Fe(001) trilayers”); EX1024 ¶¶108, 121; *supra* §II.D.1.

One of skill would have found it obvious to replace Bowen’s first ferromagnetic material layer (Fe layer) with a CoFeB ferromagnetic layer as taught by Sunai to increase TMR. EX1030 ¶¶28 (teaching CoFeB electrode by adding B to Co<sub>9</sub>Fe), 24 (teaching “ferromagnetic layer 4 is represented by the general formula (CoFe)<sub>100-x</sub>Y<sub>x</sub>” and specifying Y is an “element selected from the group consisting of B” or other elements); *id.* ¶¶25-29; EX1024 ¶124. Cobalt and iron were known ferromagnetic materials. EX1030 ¶33; EX1026 at 1655; EX1024 ¶124.

Bowen sought to increase the TMR in its MgO MTJ, EX1026 at 1655, 1657, and understood that the properties of the MTJ’s electrodes contributed to improve

the tunneling and hence TMR of its device, EX1026 at 1657; EX1024 ¶¶125, 127. A skilled artisan knew that using CoFeB electrodes improved TMR. EX1024 ¶¶126, 128. 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* EX1024 ¶128. 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 ¶128.

One of skill would have been motivated to replace either or both of Bowen’s electrodes with CoFeB to increase TMR. 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.”); EX1024 ¶128. 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 Bowen’s MTJ because both Bowen and Sunai focused on improving the TMR of magnetoresistive devices, a problem to which the ’198 Patent was directed. EX1026 at Abstract, 1655; EX1030 at Abstract, ¶¶1, 10; EX1009 at Abstract, 1:30-2:28. Both were directed to

improving MRAM memory performance, as was the '198 Patent. EX1026 at 1655; EX1030 at Figs. 4-5, ¶¶1, 4, 37-40; EX1009 at 1:57-59; EX1024 ¶125. Both used ferromagnetic alloy electrodes. EX1026 at Abstract, 1655; EX1030 ¶¶24, 35; EX1024 ¶125. 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 the TMR in Bowen's MTJ. EX1024 ¶130; EX1030 ¶¶24-29; EX1055 at 2269-70; EX1056 ¶¶39, 78.

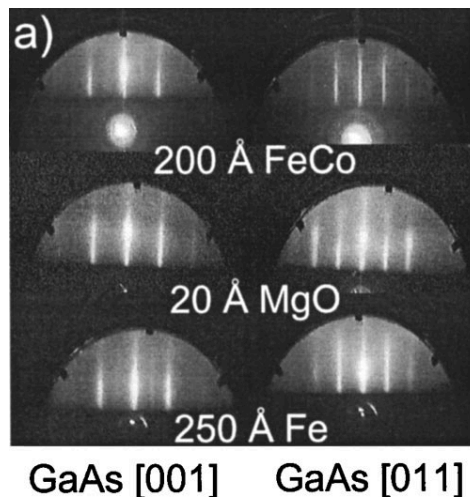
Additionally, it was known that use of CoFeB adjacent to crystalline MgO produced bcc CoFeB crystalline structures. EX1060 at 310; EX1062 at 18:55-59 (describing the effect of using CoFeB adjacent to MgO crystal structure as the MgO “provides a template for the formation of a thin crystalline ferromagnetic layer which has the bcc structure of CoFe and is oriented in the same (100) direction as the MgO layer”); EX1009 at 4:39-41 (MgO (001), (100), (010) planes are the same). Thus, substitution of CoFeB for Fe would still produce a bcc CoFeB structure.

4. **Claim 1[c]: “wherein the first ferromagnetic material layer is located between the tunnel barrier layer and the substrate.”**

Bowen taught or suggested a first ferromagnetic material layer (Fe) located between the MgO tunnel barrier and a MgO-GaAs(001) substrate: “FeCo/MgO/Fe epitaxial structures were grown on GaAs(001) in a combined sputtering/laser ablation system....” EX1026 at 1655; *id.* at Abstract, Fig. 1; EX1009 at Abstract (describing MgO substrate); EX1024 ¶¶131-34. Bowen taught using a gallium arsenic (GaAs) substrate and analyzed the “FeCo/MgO/Fe epitaxial structure,” shown below, “along the GaAs [100] and [110] *substrate*.” EX1026, Fig. 1 (excerpted). Additionally, Bowen taught its MTJ layers are “grown epitaxially onto MgO(001)-buffered GaAs(001)” substrate.

EX1026 at 1656; EX1024 ¶132. And Bowen taught growing a 20 Å thick MgO(001) tunnel barrier layer on top of its “Fe bottom electrode.” EX1026 at 1655; *id.* at Abstract, Fig. 1. Thus,

Bowen’s Fe bottom layer (first ferromagnetic material layer) would be between the MgO-GaAs substrate and the MgO tunnel barrier layer, as shown in Figure 1 above.



**B. Claim 2: “The tunnel barrier layer according to claim 1, wherein a barrier height of the tunnel barrier layer is in a range of 0.2 to 0.5 eV.”**

This limitation requires a tunnel barrier height “in a range of 0.2 to 0.5 eV.” EX1009 at 10:19-20. 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 ¶¶136-38; *supra* §II.C.

Bowen in view of Sunai and Soukup taught or suggested a tunnel barrier height for an MgO barrier layer in the claimed range of 0.2 to 0.5 eV. EX1024 ¶¶139-140. Bowen “place[d] the barrier height at  $\phi = 0.9$  eV” for its MgO barrier device. EX1026 at 1656; EX1024 ¶140. Soukup observed a “barrier height” within the claimed range of “*about 0.33 eV*” for its MgO barrier. EX1028 at Abstract; *id.* at 3231-32, Fig. 5, Table I; EX1024 ¶140.

Soukup taught that oxygen vacancy defects had an impact on the barrier height for MgO. EX1024 ¶141. 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 ¶141. In other words, Soukup suggested a higher level of oxygen vacancy defects lowered the barrier height. *See id.* One of skill reading Soukup would understand there was a relationship between oxygen vacancy defects and barrier height. EX1024 ¶141.

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 ¶142. According to the equation for TMR, lowering the resistance (barrier height) for parallel electrons ( $R_p$ ) would increase TMR. EX1035 at 3273; EX1027 ¶2; EX1009 at 4:62-5:3; EX1024 ¶142. TMR was an "important parameter" for improving MRAM performance. EX1055 at 2269; EX1024 ¶143. 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 ¶143; *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 (enhanced tunneling with "only a small lattice mismatch of about 3.5%" between electrodes and barrier); EX1024 ¶143. 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 ¶144. 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 ¶144. Indeed, both Bowen and Soukup studied

properties of MgO barriers and were focused on improving tunneling devices, the problem to which the '198 Patent was directed. EX1026 at Abstract, 1655-57; EX1028 at 3229-30; EX1009 at Abstract, 1:30-2:28.

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 ¶145. Soukup fabricated an MgO barrier with a barrier 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 ¶145. One of skill would have predictably followed the trail blazed by Bowen and Soukup. *Id.*

The claimed tunnel barrier height range of 0.2 to 0.5 eV also would have been obvious. EX1024 ¶¶146-51. 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, could be due to the "presence of stoichiometric... inhomogeneities in the insulating film." EX1026 at 1656; EX1024 ¶146. 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 increase TMR by lowering the barrier height as taught by Soukup.

Further, the '198 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... 0.2 to 0.5 eV), which is thought to result in an increase in the tunneling current.” EX1009 at 7:7-11. Thus, according to the '198 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. Additionally, in the co-pending litigation, IP Bridge asserted that this limitation is satisfied by the mere “presence of oxygen vacancy defects.” EX1064 at 17; *id.* at 19 (citing EX1001 at 6:47-7:2); EX1009 7:2-26 (same disclosure as in '403 Patent). 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).

This limitation was taught or suggested by Bowen in view of Soukup. IP Bridge’s statements in the district court further confirm this limitation is obvious.

### **C. Claim 3**

This claim would have been obvious over Bowen in view of Sunai and Soukup.

#### **1. Claim 3[preamble]: “The tunnel barrier layer according to claim 2,”**

*Supra* Claims 1 and 2, §§VI.A-VI.B; EX1024 ¶153.

2. **Claim 3[a]: “wherein the barrier height  $p$  of the tunnel barrier layer is obtained by fitting J-V characteristics of a tunnel barrier junction structure to an equation (1):  $J=[(2m\phi)^{1/2}/\Delta s](e/h)^2 \times \exp[-(4\pi\Delta s/h) \times (2m\phi)^{1/2}] \times V$  (1)”**

This limitation is taught or suggested by Bowen in view of Soukup. The equation in Claim 3[a] merely recites Simmons’ formula. Claim 3[a] specifies a tunnel “barrier height” with “an equation (1),” EX1009 at 10:25, and the applicant indicated during prosecution that “ $\phi$ ,” (not “ $p$ ” or “#”) represented tunnel “barrier height” in “ $J=[(2m\phi)^{1/2}/\Delta s](e/h)^2 \times \exp[-(4\pi\Delta s/h) \times (2m\phi)^{1/2}] \times V$ .” EX1010 at 252.

“[E]quation (1)” is Simmons’ corrected formula from his 1963 paper for calculating tunnel barrier height. Compare EX1009 at 10:25 (Claim 3[a]), with EX1031 at 1796-97 (Simmons’ Equation (25)); EX1059 at 1; EX1009 at 7:28-36, 7:55-65; EX1024 ¶¶155-57. The tunnel barrier height is conventionally determined by fitting the barrier’s J-V curves to Simmons’ formula. EX1031 at 1796 (“[I]f the current-voltage characteristic of a tunnel junction is known, the mean barrier height can be determined.”); EX1024 ¶¶159-60. IP Bridge agrees. E.g., EX1074 at 5, 14-15 (acknowledging “equation (1)” is “Simmons’ formula” for same limitation in ’463 Patent). EX1024 ¶158.

Bowen taught using Simmons’ formula to approximate its tunnel barrier height. He used “I(V) curves [to] place[] the barrier height at  $\phi=0.9$  eV” at 10 mV for his Fe/MgO/FeCo MTJ. EX1026 at 1656. He compared his measurements with

“Simmons’ equations” and cited to Simmons’ foundational 1963 paper. EX1026 at 1656, 1657 n.13 (citing EX1031); EX1024 ¶161. Soukup recognized “Simmons’ model” was used to evaluate the “height and the bias dependence of the insulator potential-energy barrier.” EX1028 at 3229; *id.* at 3229, 3236 n.1 (citing EX1031); EX1024 ¶162.

One of skill would have found it obvious over Bowen and Soukup to use Simmons’ formula to calculate the tunnel “barrier height”  $\phi$ .

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

Claim 3[b] specifies the variables, and some values for those variables, to use in Simmons’ formula. EX1009 at 10:27-35; EX1024 ¶¶164-65. These variables and the recited values are all obvious over Bowen.

The ’198 Patent uses the same variables from Simmons’ foundational paper, as shown in the table below:

| <b>Claim 3[b] limitations<br/>[EX1009 at 10:27-35]</b> | <b>Simmons’ formula (1963)<br/>[EX1031 at 1794]</b> |
|--------------------------------------------------------|-----------------------------------------------------|
| “J is a tunnel current density”                        | “J=tunnel current density”                          |
| “V is an applied bias voltage”                         | “V=voltage across film”                             |
| “m is the free electron mass”                          | “m=mass of electron”                                |

| Claim 3[b] limitations<br>[EX1009 at 10:27-35]                      | Simmons' formula (1963)<br>[EX1031 at 1794] |
|---------------------------------------------------------------------|---------------------------------------------|
| "e is the elementary electric charge"                               | "e=charge of electron"                      |
| "h is the Planck's constant"                                        | "h=Planck's constant"                       |
| " $\Delta s$ is an effective thickness of the tunnel barrier layer" | " $\Delta s = s_2 - s_1$ "                  |

Compare EX1009 at 10:27-35, with EX1031 at 1794 (defining variables); EX1024 ¶166.

Calculating a barrier height using Simmons' formula with Simmons' variables would have been obvious. EX1024 ¶165. Indeed, Simmons' 1963 paper told one of skill how to calculate barrier height in exactly this manner. EX1031 at 1794-97; EX1024 ¶165. As explained for Claim 3[a], both Bowen and Soukup observed Simmons' formula was used to calculate barrier height. *Supra* §VI.C.2; EX1024 ¶165.

None of the requirements of Claim 3[b] are inventive:

Claim 3[b] recites that "J is a tunnel current density flowing through the tunnel barrier layer." EX1009 at 10:27-28. One of skill would understand the '198 Patent is restating Simmons' variable: "J=tunnel current density." EX1031 at 1794; EX1024 ¶167-68. Simmons explained that "[t]he purpose of this paper is to derive a single theory for the *current flow through a generalized barrier*." EX1031 at 1794; EX1024 ¶168.

Claim 3[b] further recites: “V is an applied bias voltage that is 100 mV or smaller.” EX1009 at 10:28-29. Applying a low voltage of under 100 mV would have been obvious. Indeed, Simmons provided the equation (25) recited in Claim 3[a] for a “Low-Voltage Range:  $V \approx 0$ ” for “low voltages.” EX1031 at 1797; EX1024 ¶170. “100 mV or smaller” is a low voltage. EX1024 ¶¶159, 170.

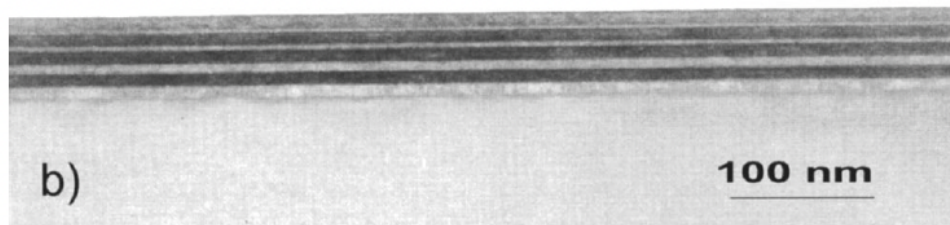
Applying a bias voltage “100 mV or smaller” across a junction further is obvious over Bowen. EX1024 ¶169. Bowen measured the barrier height in the claimed range “at 10 mV.” EX1026 at 1656. As shown in Figure 3, Bowen also applied various bias voltages to its MTJ, including spanning 0 to 100 mV, finding the highest TMR “value of 60% at 10 mV.” EX1026 at Fig. 3, 1657; EX1024 ¶169.

This limitation also requires: “ $\Delta s$  is an effective thickness of the tunnel barrier layer that is approximately equivalent to  $(t_{MgO} - 0.5 \text{ nm})$ .” EX1009 at 10:31-32. One of skill would understand that Simmons’  $\Delta s$  variable is an “effective thickness”; he defined it as “ $\Delta s = s_2 - s_1$ ” where “ $s_1, s_2$ =limits of barrier at Fermi level.” EX1031 at 1794; EX1024 ¶171.

Having a tunnel barrier layer with an effective thickness “that is approximately equivalent to  $(t_{MgO} - 0.5 \text{ nm})$ ” would have been obvious over Bowen. EX1024 ¶172. According to Claim 3[b],  $t_{MgO}$  is an “actual thickness of the tunnel barrier layer.” EX1009 at 10:33; *see also* EX1031 at 1794 (“ $s$ =thickness of insulating film”); EX1024 ¶172. Bowen taught an effective thickness of the barrier

of approximately 0.5 nm less than the actual barrier thickness. He fabricated an Fe/MgO/FeCo MTJ with an MgO barrier of “20 Å” or 2 nm. EX1026 at 1656; EX1024 ¶172. He used Simmons’ equations to calculate “a barrier thickness  $d \sim 15$  Å,” or 1.5 nm, for his MTJ. *Id.* Bowen’s effective thickness was approximately 0.5 nm less than the actual thickness: 2 nm actual – 0.5 nm = 1.5 nm effective. *See id.*

Finally, Claim 3[b] requires that “ $t_{MgO}$  is an actual thickness of the tunnel barrier layer determined using a cross-sectional transmission electron microscope image.” EX1009 at 10:33-35. This limitation is also obvious over Bowen, who expressly recognized that MgO layer thickness could be measured using “cross section transmission electron microscopy (TEM)”:



EX1026 at 1655, Fig. 1 (excerpted); EX1024 ¶173.

Applying Simmons’ formula from his foundational paper would have been obvious to a skilled artisan, as demonstrated by Simmons and Bowen.

- D. Claim 4: “The tunnel barrier layer according to claim 1, wherein the second ferromagnetic material layer is composed of an alloy comprising Fe and Co, and wherein the second ferromagnetic material layer is located above the tunnel barrier layer.”**

Claim 4 does not specify any molecular composition or stoichiometry of the claimed “alloy comprising Fe and Co,” and thus any bcc CoFe alloy satisfies it. EX1009 at 10:35-40; EX1024 ¶176.

This claim was disclosed or suggested by Bowen in view of Sunai for the reasons provided in Claims 1[preamble], 1[b], and 1[c]. *Supra* §§VI.A.1, VI.A.3-VI.A.4; EX1024 ¶¶175-76.

Bowen taught a second ferromagnetic material (FeCo) located above the MgO tunnel barrier layer. Bowen disclosed fabricating its MTJ by epitaxially growing its “Fe(200 Å)/MgO(20 Å)/FeCo(250 Å) trilayer” by first depositing the “Fe bottom electrode” onto a substrate, then depositing the MgO barrier on top of the “Fe bottom electrode,” followed by an “FeCo” electrode deposited on top of the MgO barrier. EX1026 at 1655-56; *id.* Abstract, Fig. 1; EX1024 at ¶177; *supra* §VI.A.4.

- E. Claim 5: “The tunnel barrier layer according to claim 1, wherein the second ferromagnetic material layer is composed of an alloy comprising Fe, Co, and B, and wherein the second ferromagnetic material layer is located above the tunnel barrier layer.”**

Claim 5 does not specify any molecular composition or stoichiometry of the claimed “alloy comprising Fe, Co, and B,” and thus any bcc CoFeB alloy satisfies it. EX1009 at 10:40-45; EX1024 ¶178.

This claim was disclosed or suggested by Bowen in view of Sunai for the reasons provided in Claims 1[preamble], 1[b], 1[c], and 4. *Supra* §§VI.A.1, VI.A.3-VI.A.4, VI.D; EX1024 ¶178.

**F. Claim 6: “The tunnel barrier layer according to claim 1, wherein the tunnel barrier layer is disposed on the first ferromagnetic material layer.”**

This claim was disclosed or suggested by Bowen in view of Sunai for the reasons provided in Claims 1[preamble] and 1[c]. *Supra* §§VI.A.1, VI.A.4; EX1024 ¶179.

**VII. GROUND 2: CLAIMS 1-6 ARE OBVIOUS OVER NAGAHAMA IN VIEW OF SUNAI (AND 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). 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.” *Id.* ¶1; EX1024 ¶200. It would have been obvious to a skilled artisan to use Nagahama’s teachings regarding MTJs to form a single structure satisfying Claim 1, as discussed below.

**A. Claim 1**

Claim 1 would have been obvious over Nagahama in view of Sunai.

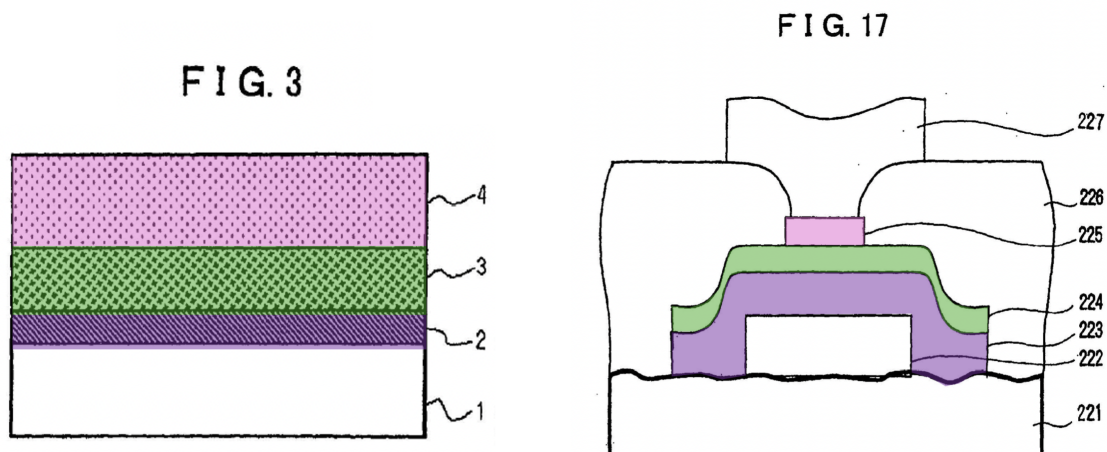
1. **Claim 1[preamble]: “A tunnel barrier layer disposed between a first ferromagnetic material layer and a second ferromagnetic material layer that are disposed over a substrate,”**

To the extent limiting, Nagahama taught or suggested a tunnel barrier layer disposed between two ferromagnetic material layers that are all collectively disposed over a substrate as claimed. EX1027 ¶¶73-74, Abstract, Claim 1; EX1024 ¶¶183-85. As explained in Ground 1, MTJs were well known in the art. EX1024 ¶182; *supra* §§II.B, VI.A.1.

The “ferromagnetic material layer” refers to an electrode made of a “ferromagnetic metal.” EX1009 at 1:45-49, Fig. 8(a); EX1024 ¶186; *supra* §II.B. The “tunnel barrier layer” refers to “an oxide [that] is sandwiched between a first and a second electrode made of a ferromagnetic metal.” EX1009 at 1:45-49. “First” refers to the “lower” ferromagnetic electrode that is closest to the substrate, and “second” refers to the “upper” ferromagnetic electrode. EX1009 at Abstract; EX1024 ¶186.

Nagahama disclosed “a (001)-highly-oriented lower ferromagnetic electrode layer, a (001)-highly-oriented MgO barrier layer, and a (001)-highly-oriented upper ferromagnetic electrode layer on the MgO double underlayer of the present invention.” EX1027 ¶73. Such an arrangement is depicted in Figures 3 and 17 as well. EX1027 ¶¶21-22, 75-76; EX1024 ¶¶187-89. 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 ¶187.



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

Nagahama taught that its “**lower ferromagnetic electrode**” of its “high-quality tunnel magnetoresistive element” was the “first ferromagnetic layer” and its “upper ferromagnetic electrode” was the “second ferromagnetic layer.” EX1027 ¶¶75-76, Fig. 17; *see also id.* ¶22, Fig. 3 (describing the same relationships); EX1024 ¶188. Nagahama discloses various examples of this “lower ferromagnetic electrode” material, including Fe, Co, Ni, or an alloy of these metals. *E.g.*, EX1027 ¶¶28, 31, 61, 68, Fig. 17 (reference numeral 223).

In the example of paragraphs 73-74, Nagahama taught that its “(001)-highly-oriented **upper** ferromagnetic electrode layer” was disposed over its “(001)-highly-oriented MgO barrier layer,” and this highly-oriented MgO barrier was disposed

over the “(001)-highly-oriented *lower* 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 ¶190. Consequently, Nagahama also disclosed an MTJ with a tunnel barrier that was disposed between first and second ferromagnetic material layers.

**2. Claim 1[a]: “wherein the tunnel barrier layer comprises a poly-crystalline magnesium oxide layer in which a (001) crystal plane is preferentially oriented,”**

Nagahama disclosed or suggested this limitation.

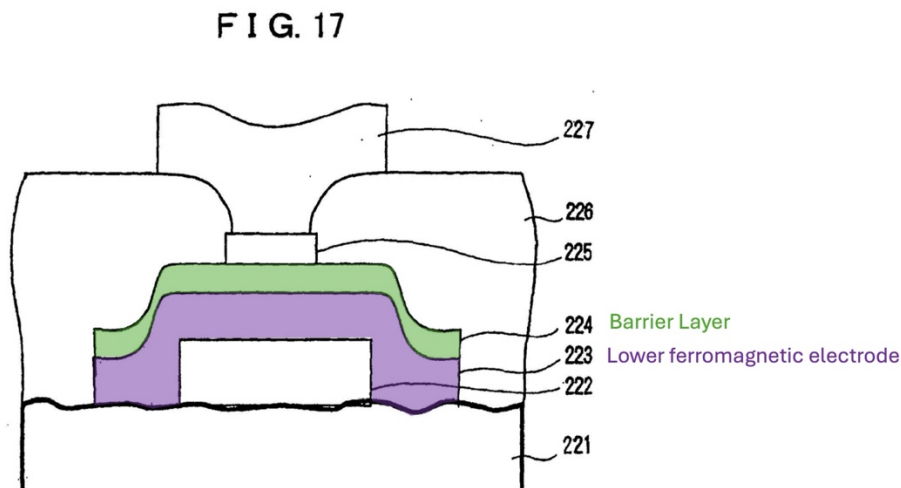
Nagahama taught a polycrystalline MgO(001) tunnel barrier layer in its magnetoresistive element: “a (001)-highly-oriented MgO barrier layer.” EX1027 ¶73; EX1024 ¶192. Because single-crystal layers have the same orientation throughout the crystalline lattice, “highly-oriented” is a term that describes the predominant orientation of a polycrystalline layer containing many crystals. EX1024 ¶193; EX1040 at 2842 (MgO “polycrystalline structures” have “preferred orientation”). Nagahama describing its tunnel barrier layer as “a (001)-highly-oriented MgO barrier layer,” EX1027 ¶73, confirms its MgO barrier was polycrystalline and preferentially oriented in the (001) plane, EX1024 ¶¶192-93.

**3. Claim 1[b]: “wherein the first ferromagnetic material layer is composed of an Fe—Co alloy of BCC which alloy comprises Fe, Co, and B,”**

This limitation is taught or suggested by Nagahama in view of Sunai.

Claim 1[b] does not specify any molecular composition or stoichiometry of the claimed alloy “comprising Fe, Co, B,” and thus any bcc CoFeB alloy satisfies it. EX1009 at 10:13-15; EX1024 ¶122.

Nagahama disclosed a “(001)-highly-oriented *lower* ferromagnetic electrode” formed on a first (lower) side of the tunnel barrier layer. EX1027 ¶73. Nagahama discloses various examples of this “*lower ferromagnetic electrode*” material, including Fe, Co, Ni, or an alloy of these metals. *E.g.*, EX1027 ¶¶28, 31, 61, 68, Fig. 17 (reference numeral 223).



EX1027 at Fig. 17 (annotated).

One of skill would have found it obvious to replace Nagahama’s lower ferromagnetic electrode material with CoFeB as taught by Sunai. EX1030 ¶¶25-29; EX1024 ¶195.

One of skill would have been motivated to substitute Sunai's CoFeB electrode for Nagahama's lower electrode (made of Fe, Co, Ni or combinations thereof) to increase the TMR of Nagahama's MTJ. EX1024 ¶¶196-97. 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 ¶197. As explained for Claim 1[b] in Ground 1, a skilled artisan knew that using CoFeB electrodes improved TMR. *Supra* §VI.A.3; EX1030 ¶27; EX1035 at 3274; EX1055 at 2269-70; EX1056 ¶¶39, 78; EX1024 ¶197.

One of skill would have been motivated to replace either or both of Nagahama's upper and lower electrodes with CoFeB to increase TMR. EX1055 at 2270 ("[I]t is natural to replace both the free and pinned layers to CoFeB to further increase the TMR value."); EX1056 at ¶¶67-68; EX1035 at 3274; EX1024 ¶197. 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 ¶198. Both Nagahama and Sunai focused on improving the TMR of magnetoresistive devices, a problem to which the '198 Patent was directed. EX1027 ¶¶6, 15; EX1030 at Abstract, ¶¶1, 10; EX1009 at Abstract, 1:30-2:28. Both were directed to improving MRAM memory performance, as was the '198 Patent. EX1027 ¶¶3, 49; EX1030 at Figs. 4-5, ¶¶1, 4, 37-40; EX1009 at 1:57-59; EX1024 ¶198. Both used the same MgO barrier layer and similar ferromagnetic alloy

electrodes. EX1027 ¶¶ 6, 73; EX1030 ¶¶24, 35; EX1024 ¶198. 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 ¶199; EX1030 ¶¶24-29; EX1055 at 2269-70; EX1056 ¶¶39, 78.

Despite replacing the material as recommended by Sunai, one of skill would have heeded Nagahama's recommendation that the electrode material layer portions of its tunnel magnetoresistive element remain "set to the (001) direction of a *body-centered cubic lattice*" as taught by Nagahama. EX1027 ¶1, 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*, ... and using a (001)-highly-oriented MgO layer as a barrier layer, a large magnetoresistive effect is produced."); EX1060 at 310; EX1062 at 18:55-59 (MgO barrier provides template for bcc CoFeB electrode); EX1024 ¶¶200-202.

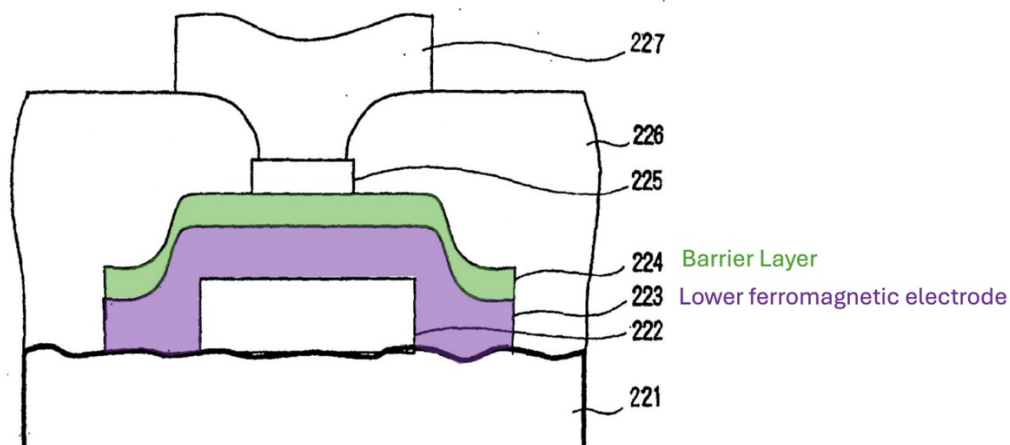
**4. Claim 1[c]: "wherein the first ferromagnetic material layer is located between the tunnel barrier layer and the substrate."**

Nagahama's first ferromagnetic material layer was located between the tunnel barrier layer and the substrate. Nagahama's paragraphs 73-74 embodiment described a MgO double underlayer substrate and a (001)-highly-oriented MgO barrier layer that together sandwiched a (001)-highly-oriented lower ferromagnetic

electrode layer. EX1027 ¶73; *supra* §VII.A.1 (Claim 1[preamble] in Ground 2); EX1024 ¶204.

Nagahama described another example of its invention with respect to Figure 17 depicted below, which showed that the lower ferromagnetic electrode 223 is located between the MgO double underlayer substrate 222 and the barrier layer 224. EX1027 ¶76, Fig. 17; EX1024 ¶205.

**FIG. 17**



EX1027 at Fig. 17 (annotated).

**B. Claim 2: “The tunnel barrier layer according to claim 1, wherein a barrier height of the tunnel barrier layer is in a range of 0.2 to 0.5 eV.”**

As explained in Ground 1, Claim 2 requires a tunnel barrier height “in a range of 0.2 to 0.5 eV.” EX1009 at 10:19-20; *supra* §§VI.B, II.C.

Nagahama in view of Sunai and Soukup taught or suggested an MgO tunnel barrier height for an MgO barrier layer in the claimed range of 0.2 to 0.5 eV. EX1024

¶¶207-208. Nagahama taught an MgO MTJ. EX1027 ¶¶21-22, 73-76, 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 ¶208. As explained for Claim 2 in Ground 1, one of skill reading Soukup understood there was a relationship between oxygen vacancy defects and barrier height. *Supra* §VI.B; EX1028 at Abstract, 3232, 3236; EX1024 ¶209.

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. EX1024 ¶210. According to the equation for TMR, lowering the resistance (barrier height) for parallel electrons ( $R_p$ ) would increase TMR. EX1035 at 3273; EX1027 ¶2; EX1009 at 4:62-5:3; EX1024 ¶211. TMR was an “important parameter” for improving MRAM performance. EX1055 at 2269; EX1024 ¶211. Skilled artisans had long been interested in increasing TMR to enable better performing MRAM. EX1055 at 2271; EX1024 ¶211; *supra* §II.B. Nagahama’s stated goal was to increase TMR in its MTJ. EX1027 ¶¶15 (“a first object of the present invention is to provide a tunnel magnetoresistive element capable of producing a larger magnetoresistive effect”), 6 (goal of “obtain[ing] a high magnetoresistive effect”), 3-8; EX1024 ¶212. 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.

Butler and Mathon taught that MgO barriers would achieve higher TMRs due to improved symmetry matching between the MgO barrier and ferromagnetic electrode, facilitating tunneling of parallel electrons across the barrier compared to antiparallel tunneling. EX1044 at 1; EX1046 at 1 (enhanced tunneling with “only a small lattice mismatch of about 3.5%” between electrodes and barrier); EX1024 ¶143. 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 ¶212. Thus, one of skill seeking to improve Nagahama’s MTJ would have looked to Soukup’s teachings about MgO barriers and how defects lowered the barrier height. EX1024 ¶212. 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 ’198 Patent was directed. EX1027 ¶¶2-4, 13-15; EX1028 at 3229-30; EX1009 at Abstract, 1:30-2:28.

One of skill would have had a reasonable expectation of success in achieving a tunnel barrier height in the claimed range in Nagahama’s MTJ. EX1024 ¶¶214-19. Soukup fabricated an MgO barrier with a barrier height of 0.33 eV, EX1028 at Abstract, and that the barrier height would be varied by adjusting the oxygen vacancy defects in the MgO barrier layer, EX1028 at Abstract, 3232, 3236; EX1024

¶¶213, 218-220. One of skill would have predictably followed this trail. EX1024 ¶221.

For the same reasons explained for Claim 2 in Ground 1, the claimed tunnel barrier height range of 0.2 to 0.5 eV also would have been obvious. *Supra* §VI.B; EX1028 at 3232, 3236; EX1043 at 1; EX1045 at 7; EX1047 at 510-11; EX1051 at 1; EX1026 at 1656; EX1053 at 8042-43; EX1024 ¶218.

As explained in Ground 1, the '198 Patent's assertion that this limitation is inherent when there are oxygen vacancy defects and Patent Owner's district court statements that the claim requirement of a 0.2 to 0.5 eV barrier height is satisfied by the mere "presence of oxygen vacancy defects" also show this limitation is obvious. EX1009 at 7:7-11; EX1064 at 19 (citing EX1001 at 6:47-7:2); EX1009 7:2-26 (same disclosure as in '403 Patent); *supra* §VI.B (Claim 2 in Ground 1); *Longhorn Vaccines*, IPR2021-00847, Paper 13 at 23.

This limitation was taught or suggested by Nagahama in view of Soukup. IP Bridge's statements in the district court further confirm this limitation is obvious.

### **C. Claim 3**

Claim 3 would have been obvious over Nagahama in view of Sunai and Soukup.

#### **1. Claim 3[preamble]: "The tunnel barrier layer according to claim 2,"**

*Supra* Claims 1 and 2, VII.A-VII.B; EX1024 ¶223.

2. **Claim 3[a]: “wherein the barrier height  $p$  of the tunnel barrier layer is obtained by fitting J-V characteristics of a tunnel barrier junction structure to an equation (1):  $J=[(2m\phi)^{1/2}/\Delta s](e/h)^2 \times \exp[-(4\pi\Delta s/h) \times (2m\phi)^{1/2}] \times V$  (1)”**

This limitation is obvious over Nagahama in view of Sunai and Soukup.

Nagahama taught an MgO MTJ. EX1027 ¶¶73-74. Nagahama’s stated goal was to increase TMR in its MTJ. EX1027 ¶¶15 (“a first object of the present invention is to provide a tunnel magnetoresistive element capable of producing a larger magnetoresistive effect”), 6 (goal of “obtain[ing] a high magnetoresistive effect”), 3-8; EX1024 ¶¶226-27. Nagahama sought to increase TMR by modifying properties of the MgO barrier layer. EX1027 ¶¶15-17. Indeed, skilled artisans were interested in determining the barrier height, as it was understood that there was a relationship between the barrier height and higher TMR. EX1045 at 4; EX1047 at 510-11; EX1051 at 1; EX1024 ¶228.

Skilled artisans were also aware that Simmons’ formula was used to approximate the barrier height of an MTJ. *Supra* Ground 1, Claim 3[a], §§VI.C.2; *see also* §II.C. Indeed, Soukup recognized “Simmons’ model” was used to evaluate the “height and the bias dependence of the insulator potential-energy barrier.” EX1028 at 3229, 3236 n.1 (citing EX1031); EX1024 ¶229.

Because those of skill understood that Simmons’ formula was the operative equation for calculating barrier height, one of skill would have found it obvious over

Nagahama, Sunai, and Soukup to use Simmons' formula to calculate the "tunnel barrier height  $\phi$ ."

3. **Claim 3[b]: "where J is a tunnel current density flowing through the tunnel barrier layer, V is an applied bias voltage that is 100 mV or smaller, m is the free electron mass, e is the elementary electric charge, h is the Planck's constant,  $\Delta s$  is an effective thickness of the tunnel barrier layer that is approximately equivalent to ( $t_{\text{MgO}} - 0.5$  nm), and  $t_{\text{MgO}}$  is an actual thickness of the tunnel barrier layer determined using a cross-sectional transmission electron microscope image."**

As explained, Claim 3[b] specifies the variables, and some values of those variables, to use in Simmons' formula. *Supra* Ground 1, Claim 3[b], §§VI.C.3; *see also* §II.C; EX1024 ¶¶231-32. These variables, and the recited values, are all obvious over Nagahama in view of Sunai and Soukup. A skilled artisan understood the variables in Claim 3[b] based on Simmons' foundational paper (EX1031) and understood how to apply them. *Id.* To the extent that Ground 1's rationale relies on Bowen's application of Simmons' formula, such application would have been within the knowledge of a skilled artisan as expressly referenced by Nagahama: "[A] giant tunnel magnetoresistive effect of more than 60% has been experimentally obtained (M. Bowen et al., Applied Physics Letters, volume 79, number 11 (2001), pages 1655-1657)." EX1027 ¶14. Thus, applying Simmons' formula from his foundational paper would have been obvious, as demonstrated by Nagahama, Sunai,

and Soukup as well as the knowledge of a skilled artisan in Simmons and Bowen.  
EX1024 ¶233.

**D. Claim 4: “The tunnel barrier layer according to claim 1, wherein the second ferromagnetic material layer is composed of an alloy comprising Fe and Co, and wherein the second ferromagnetic material layer is located above the tunnel barrier layer.”**

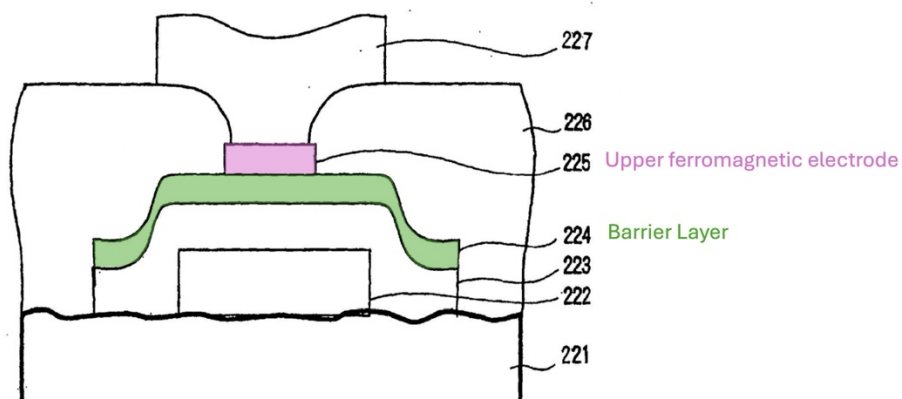
This claim was disclosed or suggested by Nagahama in view of Sunai for the reasons explained here and those provided in Claims 1[preamble], 1[b], and 1[c] of Ground 2. *Supra* §§VII.A.1, VII.A.3-VII.A.4; EX1024 ¶234.

As explained with respect to Claim 1, it would have been obvious to substitute CoFeB as taught by Sunai for both electrodes including Nagahama’s upper ferromagnetic electrode in Nagahama’s examples. CoFeB is an alloy comprising Fe and Co. EX1024 ¶239. Additionally, even Nagahama disclosed examples of using CoFe for upper electrodes. *E.g.*, EX1027 ¶¶68 (“FeCo polycrystalline alloy serving as an upper electrode”), 70 (“FeCo upper ferromagnetic electrode”). One of skill would have known that these were acceptable to use as an upper electrode based on Nagahama’s teachings that they were acceptable alone. EX1024 ¶238.

Nagahama’s upper ferromagnetic electrode is a second ferromagnetic material layer located above the tunnel barrier layer. Nagahama taught and depicted “a (001)-highly-oriented upper ferromagnetic electrode layer” formed on a second side of the MgO barrier layer, opposite the lower ferromagnetic electrode layer. EX1027 ¶73;

EX1024 ¶235. The same relationship is illustrated in Figure 17 for the barrier layer 224 and the upper ferromagnetic electrode 225. EX1027 ¶76.

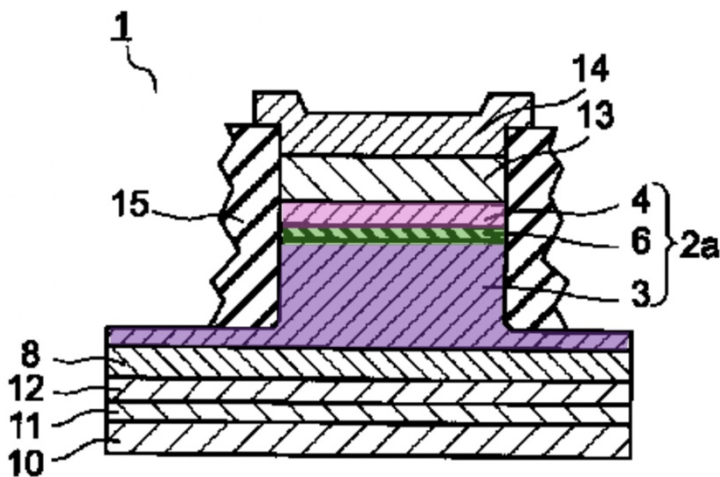
FIG. 17



EX1027 at Fig. 17 (annotated).

Sunai also taught and illustrated a ferromagnetic layer 4 [pink] that was disposed on top of a first tunnel barrier layer 6 [green]:

[Figure 1]



EX1030 at Abstract, Fig. 1 (annotated), ¶1; EX1024 ¶236.

One of skill would have found it obvious to fabricate an MTJ by starting with a substrate at the bottom and adding the following layers in succession: a first Fe electrode, an MgO tunnel barrier layer, and a second Fe-containing electrode, as this layer order was conventional. EX1009 at 1:45-49 (Description of Related Art); *id.* at Figs. 8(A)-8(B); EX1024 ¶237.

**E. Claim 5: “The tunnel barrier layer according to claim 1, wherein the second ferromagnetic material layer is composed of an alloy comprising Fe, Co, and B, and wherein the second ferromagnetic material layer is located above the tunnel barrier layer.”**

This claim was disclosed or suggested by Nagahama in view of Sunai for the reasons provided in Claims 1[preamble], 1[b], 1[c], and 4 of Ground 2. *Supra* §§VII.A.1, VII.A.3-VII.A.4, VII.D; EX1024 ¶240.

**F. Claim 6: “The tunnel barrier layer according to claim 1, wherein the tunnel barrier layer is disposed on the first ferromagnetic material layer.”**

This claim was disclosed or suggested by Nagahama in view of Sunai for the reasons provided in Claims 1[preamble] and 1[c] of Ground 2. *Supra* §VII.A.1, VII.A.4; EX1024 ¶241.

## **VIII. SECONDARY CONSIDERATIONS**

Western Digital is unaware of any relevant secondary considerations of non-obviousness for the '198 Patent. EX1024 ¶242.

## **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 in AIA Post-Grant Proceedings with Parallel District Court Litigation (June 21, 2022) (“Guidance Memo”).

IP Bridge filed its initial complaint in March 2024, and the 38-month median time to trial in the District of Delaware 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); EX1063; EX1078 at 2; 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. After Western Digital filed a motion to dismiss, IP Bridge asked for an extension and filed a First Amended Complaint on July 8, 2024. EX1077 at 3. Western Digital’s renewed motion to dismiss and motion to transfer the case to California are presently pending, and the district court has not set a date for an initial scheduling conference, let alone a trial date. *See* EX1077.

To date, IP Bridge has asserted only a single claim of the ’198 Patent in Delaware, EX1067 ¶163, 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 presented in this Petition. EX1010 at 166-167, 210-214. The Board has ample reason to conclude, either under part one or two, that *Advanced Bionics* does not apply.

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

Part one supports ordering trial here. In part one of *Advanced Bionics*, the Board considers “the similarities and material differences between the asserted art and the prior art involved during examination, the cumulative nature of the art, and the overlap of the arguments presented.” *BMW of N. Am. v. Stragent*, IPR2021-

00419, 2021 WL 3039219, at \*5 (P.T.A.B. July 19, 2021) (citing *Advanced Bionics*, 2020 WL 740292, at \*4).

The same Examiner handled prosecution of both '198 and '134 Patents. EX1005 at 1 (“*Primary Examiner*—Alonzo Chambliss”); EX1009 at 1 (same). The Examiner found Claims 1-6 not patentably distinct over Claim 1 of U.S. Patent No. 8,405,134 (“'134 Patent”). EX1010 at 213-14. During examination of the '134 Patent, the Examiner also did not consider the prior art combinations presented in this Petition. EX1006 at 143-44. Further, the '134 Patent did not include the limitation “barrier height of the tunnel barrier layer is in a range of 0.2 to 0.5 eV” as do Claims 2 and 3 of the '198 Patent.

During prosecution of the '403 Patent, the parent patent to both the '198 and '134 Patents, the Examiner believed that the claimed barrier height of 0.2 to 0.5 eV was inventive, EX1002 at 235, and applicant never informed him otherwise, *see* EX1002 at 254-60; EX1028 at Abstract (Soukup: barrier height of 0.33 eV). And the applicant never corrected the examiner during prosecution of the '198 Patent either. *See generally* EX1010. Nor was the Examiner informed of Patent Owner’s position that the “the presence of oxygen vacancy defects indicates a tunnel barrier height as claimed.” *E.g.*, EX1064 at 19 ('403 Patent infringement allegations); *see generally* EX1010.

The Examiner did not have the benefit of Soukup during examination of the '198 or '403 Patent applications, the combinations of prior art presented here, or Patent Owner's positions on the barrier height, all of which render obvious the claimed tunnel barrier height limitation in a range of 0.2 to 0.5 eV required by Claims 2-3 of the '198 Patent. *See generally* EX1010; *supra* §§VI.B, VII.B. Thus, this Petition presents new information that the Examiner did not have the opportunity to consider during his initial examination. The grounds in this Petition were not "previously presented" to the Patent Office and trial is warranted here. *See, e.g., Lifecore Fitness, LLC v. Woodway USA, Inc.*, IPR2024-00083, Paper 13 at 22 (P.T.A.B. May 17, 2024) (refusing to deny institution under step one of *Advanced Bionics* even though some of the references were cited on the face of the patent because of the Petitioner's reliance on new art that was not previously presented to the PTO); *JUUL Labs. v. NJOY*, IPR2024-00160, 2024 WL 2697567, at \*5 (P.T.A.B. May 24, 2024) (*Advanced Bionics* part one not met because "mere prior citation of prior art in an IDS will not automatically satisfy the first prong").

Claims 1-6 of the '198 Patent also require "the first ferromagnetic material layer is composed of an Fe—Co alloy of BCC which alloy comprises Fe, Co, and B." EX1009 at 10:13-15. While applicant overcame a rejection based on U.S. Patent Application Publication No. 2008/0062581 ("Parkin581") regarding this limitation, the Examiner did recognize the disclosure in the Parkin reference presented here

(EX1062), which taught that use of CoFeB adjacent to crystalline MgO produced bcc CoFeB crystalline structures. EX1060 at 310; EX1062 at 18:55-59 (describing the effect of using CoFeB adjacent to MgO crystal structure as the MgO “provides a template for the formation of a thin crystalline ferromagnetic layer which has the bcc structure of CoFe and is oriented in the same (100) direction as the MgO layer.”). Consequently, Claims 1-6 did not overcome rejections based on any of the combinations in this Petition, or potentially cumulative references.

If the Board deems consideration of step two necessary, it also supports instituting trial here. Material error by the Office “may include misapprehending or overlooking specific teachings of the relevant prior art where those teachings impact patentability of the challenged claims.” *Advanced Bionics*, 2020 WL 740292, at \*3 n.9. Indeed, the Examiner erred in a way that was material to patentability.

Allowing Claim 3 was a material oversight. The Examiner rejected Claim 3 as patentably indistinct to Claim 1 of the '134 Patent. EX1010 at 213-14. However, Claim 1 of the '134 Patent does not include a “tunnel barrier height obtained by fitting J-V characteristics of a tunnel barrier junction structure” according to Simmons’ formula, EX1005 at 10:2-15, and this limitation was never considered during the '134 Patent’s examination, EX1006 at 51, 82, 154-55. Neither was this limitation raised by the applicant or discussed by the Examiner during examination of the '198 Patent, *see generally* EX1010, despite that Simmons’ formula, variables,

and his foundational 1963 paper were expressly cited in the specification, EX1009 at 7:31-34, 7:62-65, and Simmons and Bowen were listed in an IDS, *id.* at 3.

The Examiner never rejected this claim over the prior art. *See* EX1010; *Amcol Int'l v. Oil-Dri Co.*, IPR2022-01107, Paper 10 at 12 (P.T.A.B. Dec. 5, 2022) (ordering trial where prior art “was not the subject of a rejection, or discussion in any amount of detail by the Examiner”); *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).

Additionally, the Examiner’s acceptance of the Applicant’s assertion that the prior art did not disclose a “ferromagnetic material layer is composed of an Fe-Co alloy of BCC which alloy **comprises Fe, Co, and B,**” as required by independent claim 1,” EX1010 at 202 (emphasis in original), was plainly a material error. As shown above, both Sunai and Parkin, which were not before the Examiner, disclose this feature. *E.g.*, *supra* §VI.A.3; EX1030 ¶¶28 (teaching CoFeB electrode by adding B to Co<sub>9</sub>Fe), 24 (teaching “ferromagnetic layer 4 is represented by the general formula (CoFe)<sub>100-x</sub>Y<sub>x</sub>” and specifying Y is an “element selected from the group consisting of B” or other elements); EX1062 at 18:55-59 (describing the effect of using CoFeB adjacent to MgO crystal structure as the MgO “provides a template for the formation of a thin crystalline ferromagnetic layer which has the bcc structure of CoFe and is oriented in the same (100) direction as the MgO layer”).

Although the applicant criticized the disclosure in Parkin581 admittedly as describing CoFeB but being “amorphous” and was above the tunnel barrier (*i.e.*, was the second ferromagnetic layer instead of the first as required by Claim 1), EX1010 at 203, the Parkin reference relied upon in this Petition plainly disclosed that the CoFeB layer was crystalline as noted above, EX1062 at 18:51-55 (“[A] portion of the [CoFeB] storage layer 175 adjacent to the MgO tunnel barrier 120’ has crystallized and is, moreover, textured in the same orientation as the crystalline MgO tunnel barrier.”). Additionally, Sunai disclosed using CoFeB for the first ferromagnetic layer below the tunnel barrier as did other references cited herein, which the Examiner also failed to appreciate. EX1030 ¶24 (ferromagnetic layer 4 is made of  $(\text{CoFe})_{100-x}\text{Y}_x$  where Y is B), Figs. 1, 2 (showing ferromagnetic layer 4 is below the tunnel barrier and thus is the first ferromagnetic layer required by Claim 1); *see also* 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.”). Thus, the distinctions the Applicant offered over Parkin581 could not have survived had the Examiner appreciated the teachings of Sunai and Parkin as well as the other cited references.

*Advanced Bionics* does not block the Board from considering the patentability of the '198 Patent based on the prior art presented in this Petition.

## **X. CONCLUSION**

For the reasons set forth above, Western Digital requests judgment cancelling claims 1-6 of U.S. Patent No. 9,608,198.

## **XI. GROUNDS FOR STANDING**

Western Digital hereby certifies that the '198 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 '198 Patent: *Godo Kaisha IP Bridge 1 v. Western Digital Technologies, Inc.*, No. 24-cv-00342 (D. Del. Mar. 15, 2024); *Godo Kaisha IP Bridge 1 v. Seagate Technology LLC*, No. 24-cv-00341 (D. Del. Mar. 15, 2024).

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

Petitioner provides the following designation of counsel:

| <b>Lead Counsel</b>                                                                                                                                      | <b>Backup Counsel</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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Pursuant to 37 C.F.R. §42.10(b), a Power of Attorney accompanies this Petition.

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

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

Western Digital v. Godo Kaisha IP Bridge  
IPR Petition – U.S. Patent No. 9,608,198

ARMOND WILSON LLP

Dated: August 30, 2024

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Attorneys for Western Digital Technologies, Inc.

**CERTIFICATE OF COMPLIANCE**

Pursuant to 37 C.F.R. § 42.24(d), the undersigned certifies that foregoing  
**PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 9,608,198**  
exclusive of the parts exempted as provided in 37 C.F.R. § 42.24, contains 13,585  
words and therefore complies with the type-volume limitations of 37 C.F.R. § 42.24.

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**CERTIFICATE OF SERVICE**

I hereby certify that a true and correct copy of the foregoing **PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 9,608,198** and **EXHIBITS 1001-1079**, are being served on August 30, 2024, via overnight mail on the patent owner at the correspondence address of record for U.S. Patent No. 9,608,198, as addressed below:

Stites & Harbison PLLC  
1800 Diagonal Rd., Suite 325  
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A courtesy copy is also being served by electronic mail on counsel for the patent holder in the pending litigation:

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