

Filed on behalf of Patent Owner by:

Paper No. ____

Gerald B. Hryczyn, Reg. No. 50,474

Richard F. Giunta, Reg. No. 36,149

Adam R. Wichman, Reg. No. 43,988

Thomas A. Franklin, Reg. No. 63,456

Jie Xiang, Reg. No. 74,068

WOLF, GREENFIELD & SACKS, P.C.

600 Atlantic Avenue

Boston, MA 02210

(617) 646-8000 Phone

(617) 646-8646 Fax

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

WESTERN DIGITAL TECHNOLOGIES, INC.,
Petitioner,

v.

GODO KAISHA IP BRIDGE 1,
Patent Owner.

Case No. IPR2024-01386

Patent No. 9,608,198

PATENT OWNER'S PRELIMINARY RESPONSE

TABLE OF CONTENTS

I.	INTRODUCTION	1
A.	Ground 1 (Bowen and Sunai) Fails	2
1.	Petitioner’s Assertion that Sunai Would Have Motivated a POSA to Use a <i>Crystalline</i> CoFeB Structure in Bowen Is Unsupported and Refuted by Sunai.....	2
2.	Petitioner Fails to Establish that Its Bowen-Sunai Combination Would Have Had a <i>Crystalline</i> CoFeB Structure as Alleged to Meet Limitation 1[b]	3
B.	Ground 2 (Nagahama and Sunai) Fails	5
1.	Petitioner’s Assertion that a POSA Would Have Used a <i>Crystalline</i> CoFeB Structure in Nagahama to Increase TMR is Unsupported and Refuted by Sunai.....	5
2.	Petitioner Fails to Establish that a POSA Would Have Had a Reasonable Expectation of Success in Forming the Nagahama- Sunai Combination to Have a <i>Crystalline</i> CoFeB Structure as Alleged to Meet Limitation 1[b]	7
II.	MAGNETIC TUNNEL JUNCTION DEVICES.....	9
A.	Overview	9
B.	Use in Non-Volatile Storage Devices	11
C.	“Magnetoresistance Ratio” and “Tunneling Magnetoresistance Ratio” (TMR) Describe the Same Parameter	13
III.	THE ’198 PATENT	15
A.	Disclosed Embodiments	15
B.	Challenged Claims.....	19
IV.	PERSON OF ORDINARY SKILL IN THE ART (“POSA”).....	20
V.	THE PETITION’S GROUNDS FAIL.....	20
A.	Ground 1 (Bowen-Sunai) Fails For Multiple Independent Reasons	20
1.	Ground 1 Fails Because the Petition’s Assertion that a POSA Had Reason to Combine Bowen and Sunai to Achieve a BCC Crystalline CoFeB Structure Is Unsupported.....	20

a.	Sunai Teaches Away From the Claimed Crystalline (BCC) Structure in the Ferromagnetic Layer	21
i.	Limitation 1[b] Requires that the First Ferromagnetic Layer Have a Crystalline Structure	21
ii.	Sunai Teaches a Non-crystalline CoFeB Ferromagnetic Material Layer	22
2.	Petitioner Fails to Establish that Its Bowen-Sunai Combination Has a Ferromagnetic Layer with a BCC CoFeB Structure as Alleged to Meet Limitation 1[b]	27
a.	Petitioner Alleges that Limitation 1[b] is Met by a BCC Crystalline CoFeB Structure in the Bowen-Sunai Combination	28
b.	Sunai’s CoFeB Ferromagnetic Layer Is not Crystalline and Petitioner Never Alleges that It Is.....	29
c.	Petitioner’s Assertion that Placing Sunai’s CoFeB Layer Adjacent to Bowen’s Crystalline MgO Layer Would Have Produced a BCC CoFeB Structure Fails.....	31
i.	The ’198 Patent does not support Petitioner’s argument	33
ii.	EX1060 does not support Petitioner’s argument.....	33
iii.	EX1062 does not support Petitioner’s argument.....	34
d.	Conclusion: Petitioner Fails to Establish that Its Bowen-Sunai Combination Would Have a BCC CoFeB Structure as Alleged to Meet Limitation 1[b].....	36
3.	Ground 1’s Challenges to Claims 2-6 Fail Because They Inherit the Failures for Claim 1.....	36
B.	Ground 2 (Nagahama-Sunai) Fails.....	37
1.	Nagahama.....	37
2.	Sunai Refutes Petitioner’s Unsupported Assertion that a POSA Would Have Used a <i>Crystalline</i> CoFeB Structure in Nagahama to Increase TMR.....	38
3.	Petitioner Fails to Establish that a POSA Would Have Had a Reasonable Expectation of Success in Forming the Nagahama-	

Sunai Combination to Have a <i>Crystalline</i> CoFeB Structure as Alleged to Meet Limitation 1[b]	40
4. Ground 2’s Challenges to Claims 2-6 Inherit the Failures for Claim 1.	43
VI. CONCLUSION.....	43
VII. APPENDIX: U.S. PATENT NO. 9,608,198 CLAIM LIST.....	44

TABLE OF AUTHORITIES

CASES

<i>Eli Lilly & Co. v. Teva Pharms. Int’l GmbH</i> , 8 F.4th 1331 (Fed. Cir. 2021).....	41
<i>Guangdong Alison Hi-Tech Co. v. Int’l Trade Comm’n</i> , 936 F.3d 1353 (Fed. Cir. 2019)	31, 32
<i>In re Gurley</i> , 27 F.3d 551 (Fed. Cir. 1994)	22, 26
<i>In re Kahn</i> , 441 F.3d 977 (Fed. Cir. 2006)	21
<i>KSR Int’l v. Teleflex</i> , 550 U.S. 398 (2007)	21
<i>PAR Pharm., Inc. v. TWI Pharms., Inc.</i> , 773 F.3d 1186 (Fed. Cir. 2014)	31
<i>Regents of Univ. of California v. Broad Inst., Inc.</i> , 903 F.3d 1286 (Fed. Cir. 2018)	40

LISTING OF EXHIBITS

Exhibit	Description
2001	Kittel, C., <i>Introduction to Solid State Physics</i> , 6th Edition, 1986, pgs. 13-15, 18, 23 (“Kittel”)
2002	Duke, C.B., <i>Tunneling in Solids</i> , Solid State Physics: Advances in Research and Applications, 1969, pgs. 1, 6-7, 34-35, 78-79 (“Duke”)
2003	Definition of “ferromagnetism,” Oxford English Reference Dictionary, Second Edition, pg. 513 (“Oxford English Reference Dictionary”)
2004	“Ferromagnetism,” The New Encyclopaedia Britannica: Volume 4, 15th Edition, 2003, pgs. 748-749 (“Britannica”)
2005	Zhu, J.G., et al., <i>Magnetic tunnel junctions</i> , Materials today, Volume 9, Number 11, November 2006, pgs. 36-45 (“Zhu”)
2006	Wulfhekel, W., et al., <i>Single-crystal magnetotunnel junctions</i> , Applied Physics Letters, Volume 78, Number 4, January 2001, pgs. 509-511 (“Wulfhekel”)
2007	RESERVED
2008	RESERVED
2009	Callister, W.D., <i>Fundamentals of Materials Science and Engineering, An Integrated Approach</i> , Department of Metallurgical Engineering, The University of Utah, Second Edition, 2005, pgs. 36-37, G1 (“Callister”)
2010	U.S. Patent No. 6,590,803 to Saito et al. (“the ‘803 Patent”)
2011	U.S. Patent Application Publication No. 2002/0036877 to Sakakima et al. (“Sakakima”)
2012	U.S. Patent No. 6,917,492 to Matsukawa et al. (“the ‘492 Patent”)
2013	U.S. Patent Application Publication No. 2014/0175428 to Guo, Yimin (“Guo”)

I. INTRODUCTION

The claims of the challenged patent, U.S. Patent No. 9,608,198 (the “’198 Patent”), are directed to a particular type of solid-state electronics device called a magnetic tunnel junction (“MTJ”) device. An MTJ device has an insulator—called a tunnel barrier layer—sandwiched between two ferromagnetic material layers that form electrodes for the MTJ device. MTJ devices are used in a host of applications including solid-state memory. The ’198 Patent inventor Dr. Yuasa made a better MTJ device.

All six claims in the ’198 Patent require a tunnel barrier layer disposed between first and second ferromagnetic material layers. The first ferromagnetic material layer is disposed over a substrate. A limitation in claim 1 that the Petition labels as Limitation 1[b] requires that the first ferromagnetic material layer is “composed of an Fe-Co alloy of BCC which alloy comprises Fe, Co and B.” In the claims of the ’198 Patent, “Fe” is iron, “Co” is cobalt, and “B” is boron. An alloy of Co, Fe, and B is referred to in the patent as a CoFeB alloy. “BCC” in the claim stands for “body-centered cubic” which was a well-known crystalline structure of a particular type.

The Petition presents two grounds—Grounds 1 and 2. Both fail for similar reasons.

A. Ground 1 (Bowen and Sunai) Fails

Ground 1 relies on a primary reference Bowen that discloses an MTJ device with ferromagnetic layers formed from *different* materials—*not* from a CoFeB alloy as claimed. Ground 1 relies on a secondary reference Sunai to disclose an MTJ device with an electrode formed of an CoFeB alloy.

Petitioner alleges that a POSA would have “replace[d] Bowen’s first ferromagnetic material layer (Fe layer) with a CoFeB ferromagnetic layer as taught by Sunai to increase TMR.” Petition, 33. TMR is a parameter of MTJ devices. Petitioner also alleges that the resulting combination would have had a ferromagnetic layer with a “bcc [crystalline] CoFeB” structure alleged to meet the above-discussed Limitation 1[b]. Petition, 35. Petitioner’s assertions are flatly contradicted by the very evidence the Petition relies on.

1. Petitioner’s Assertion that Sunai Would Have Motivated a POSA to Use a *Crystalline* CoFeB Structure in Bowen Is Unsupported and Refuted by Sunai

It is undisputed that Sunai’s CoFeB layer does not have a crystalline structure. Indeed, Sunai explains that the very reason boron was used in the CoFeB layer was because boron *inhibits and suppresses crystallinity*, resulting in an “amorphous” CoFeB layer that is *not* crystalline. EX1030 (“Sunai”), [0024]-[0025], [0030]. Worse yet for Petitioner, Sunai teaches that it is the amorphous (*i.e.*, non-crystalline) structure of its CoFeB layer that produced the desired

increase in the TMR parameter that Petitioner relies on to motivate Ground 1's combination. EX1030, [0030] (teaching that crystallinity in the CoFeB layer "significantly low[ered] magnetoresistance change rate," i.e., the TMR).

Thus, Sunai teaches that a ***non-crystalline*** (amorphous) CoFeB structure increases TMR and that a crystalline CoFeB structure had the exact opposite effect and undesirably lowered the TMR significantly. Ground 1's assertion that Sunai would have motivated a POSA to use a "***bcc [crystalline]*** CoFeB structure"¹ (Petition, 35) in the ferromagnetic layer of Bowen to increase TMR is unsupported and directly refuted by Sunai. Ground 1 fails for that reason alone.

2. Petitioner Fails to Establish that Its Bowen-Sunai Combination Would Have Had a *Crystalline* CoFeB Structure as Alleged to Meet Limitation 1[b]

Ground 1 also fails because Petitioner fails to establish that its Bowen-Sunai combination would have had the "bcc [crystalline] CoFeB" structure alleged to meet Limitation 1[b]. Petition, 35. Petitioner alleges that a POSA would have been motivated to replace Bowen's ferromagnetic layer "with a CoFeB ferromagnetic layer as taught by Sunai." Petition, 33. But Sunai's CoFeB layer is ***non-crystalline*** (amorphous), so replacing Bowen's ferromagnetic layer with Sunai's layer would

¹ All emphasis is added unless otherwise noted.

have yielded a ***non-crystalline*** (amorphous) CoFeB layer—not “a ***bcc*** [crystalline] CoFeB structure” as alleged to meet Limitation 1[b]. Petition, 35.

Despite Sunai’s CoFeB layer being amorphous, Petitioner alleges that because Bowen has a crystalline MgO layer, use of Sunai’s CoFeB ferromagnetic layer next to Bowen’s crystalline MgO layer would have “produced [a] ***bcc*** CoFeB ***crystalline*** structure[.]” Petition, 35. Petitioner’s allegation that this was “known” (*id.*) is not supported by Petitioner’s evidence. What Petitioner’s evidence discloses (Petition, 35 (quoting EX1062 (“Parkin”), 18:55-59)) is that if a CoFeB layer is deposited atop a crystalline MgO layer, a very thin “bcc structure of CoFe” (with ***no boron***) is formed at the interface with the MgO layer and an amorphous CoFeB structure is formed atop that thin CoFe structure. This is apparent from the very portion of EX1062 that is quoted in the Petition, which refers to a “bcc structure of CoFe”—not “a bcc CoFe**B** structure” as the Petition erroneously alleges. EX1062, 18:55-60 (“The simple cubic crystalline MgO layer thus provides a template for the formation of a thin crystalline ferromagnetic layer ***which has the bcc structure of CoFe*** and is oriented in the same (100) direction as the MgO layer. ***Nevertheless the bulk of the storage layer 175 remains amorphous . . .***”)

The Petition asserts that its Bowen-Sunai combination meets Limitation 1[b] because it has a “***bcc*** [crystalline] CoFeB structure,” but that assertion is not

supported by the Petition’s evidence. Petition, 35. Ground 1 fails for this additional reason.

B. Ground 2 (Nagahama and Sunai) Fails

Ground 2 relies on Nagahama rather than Bowen as the primary reference, but Ground 2 fails for substantially similar reasons that Ground 1 fails.

Nagahama (like Bowen) discloses an MTJ device with ferromagnetic layers formed from *different* materials—*not* from a CoFeB alloy as claimed. Ground 2 relies on the same Sunai reference as Ground 1 to disclose an MTJ device with electrodes formed of an CoFeB alloy. And Petitioner relies on the same rationale for combining the references as in Ground 1—alleging that a POSA would have “substitute[d] 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.” Petition, 52. As in Ground 1, Petitioner alleges that the resulting combination meets Limitation 1[b] because it has a *crystalline* (“body-centered cubic [bcc] lattice”) *CoFeB structure*. Petition, 53. Petitioner’s assertions are flatly contradicted by the very evidence the Petition relies on.

1. Petitioner’s Assertion that a POSA Would Have Used a Crystalline CoFeB Structure in Nagahama to Increase TMR is Unsupported and Refuted by Sunai

Petitioner does not dispute that Sunai’s CoFeB layer does not have a crystalline structure. But Petitioner alleges that the Nagahama ferromagnetic

layer—which is “replace[d]” in the Nagahama-Sunai combination—does have a crystalline BCC structure. Petition, 52-53. Petitioner alleges that “[d]espite replacing the material as recommended by Sunai, one of skill would have heeded Nagahama’s recommendation” that the ferromagnetic layer “remain” as a crystalline BCC structure. Petition, 53.

Petitioner asserts that its combination that yields a BCC *crystalline* CoFeB layer is obvious because it is a “combination of familiar elements.” Petition, 52. That is simply untrue—Petitioner presents no evidence of a BCC crystalline CoFeB structure. The hindsight in Petitioner’s rationale is apparent. Petitioner picks and chooses various aspects of the references—the CoFeB “material” from Sunai and the crystalline structure from Nagahama—and alleges that a POSA would have put them together in a way not taught by either reference (or *any* evidence of record) to form a BCC *crystalline* CoFeB structure. The Petition’s own evidence lays bare that a POSA would have done no such thing.

As explained in connection with Ground 1, Sunai specifically teaches that an amorphous (i.e., *non-crystalline*) structure of its CoFeB layer is critical for producing the desired *increase* in TMR that Petitioner relies on to motivate its combinations because crystallinity in the CoFeB layer significantly *lowered* the TMR. EX1030, [0030]. Petitioner’s assertion that a POSA would have used Sunai’s CoFeB “material” in Nagahama to increase TMR but would have formed a

“body-centered cubic lattice” *crystalline* CoFeB structure (Petition, 52-53) is directly refuted by Sunai. A POSA would have done no such thing. Ground 2 fails for that reason alone.

2. Petitioner Fails to Establish that a POSA Would Have Had a Reasonable Expectation of Success in Forming the Nagahama-Sunai Combination to Have a *Crystalline* CoFeB Structure as Alleged to Meet Limitation 1[b]

Ground 2 also fails because Petitioner fails to establish that a POSA would have had a reasonable expectation of success in forming its Nagahama-Sunai combination to have a CoFeB layer with a BCC crystalline structure as alleged to meet Limitation 1[b]. Petition, 53.

It is black-letter law that establishing obviousness requires establishing a reasonable expectation of success in forming the combination alleged to meet the claim. Petitioner only alleges that it would have been “straightforward” and “predictable” to use Sunai’s CoFeB alloy to form the ferromagnetic electrodes of Nagahama’s MTJ device. Petition, 53. But Sunai teaches that its CoFeB layer is *non-crystalline* and that the presence of boron in the alloy inhibits and suppresses crystallinity. EX1030, [0024]-[0025], [0030]. Petitioner alleges that a POSA had a reason to want to make Sunai’s CoFeB layer in a BCC crystalline structure. But establishing a reasonable expectation of success is a separate *independent* requirement to establish obviousness and Petitioner ignores that requirement entirely. The Petition never even alleges that a POSA would have reasonably

expected to have succeeded in forming a BCC *crystalline* CoFeB layer despite Sunai's teaching that boron inhibits and suppresses crystallinity. Petition, 53.

Even if the Board were to read the Petition as alleging a reasonable expectation of success in forming a crystalline CoFeB layer (it did not), Petitioner presented no *evidence* establishing a reasonable expectation of success in forming a BCC *crystalline* CoFeB layer. Petitioner does not cite a single reference that describes a BCC crystalline CoFeB layer. Ground 2 relies on the same Parkin reference (EX1062) that Ground 1 cited to purportedly teach what happens when a CoFeB layer is deposited atop a crystalline MgO layer. Petition, 53. But unlike its Ground 1 argument that quoted directly from EX1062 and thereby revealed that EX1062 teaches formation of a thin crystalline *CoFe* layer without boron (EX1062, 18:51-62), in Ground 2 the Petition simply mischaracterizes the reference as teaching a "bcc [crystalline] CoFeB electrode" where there is boron in the crystalline structure. Petition, 53. EX1062 discloses no such thing.

Thus, the Petition asserts that its Nagahama-Sunai combination meets Limitation 1[b] because it has a "*body-centered cubic lattice*" crystalline CoFeB structure, but Petitioner fails to carry its burden to establish that a POSA would have reasonably expected success in forming such a structure. Petition, 53 (emphasis in original). Ground 2 fails for this additional reason.

* * *

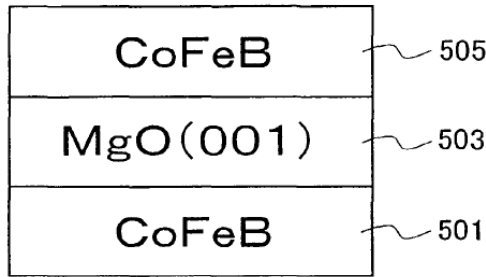
As detailed below, Petitioner fails to carry its burden to demonstrate that it is reasonably likely to prevail in demonstrating any challenged claim unpatentable. Institution should be denied.

II. MAGNETIC TUNNEL JUNCTION DEVICES

A. Overview

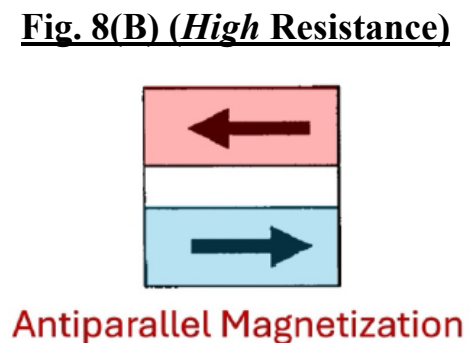
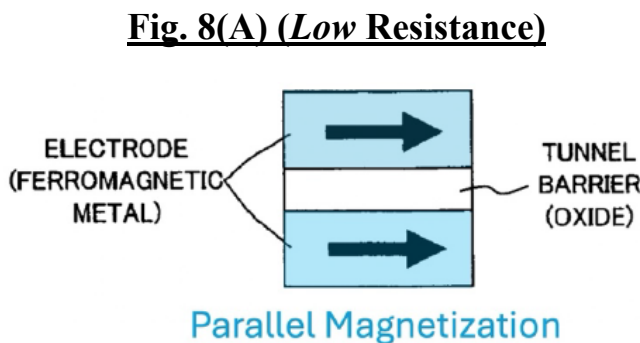
A magnetic tunnel junction device is a special kind of solid-state electronics device. It has an insulator—called a tunnel barrier layer—sandwiched between two ferromagnetic electrodes. EX1009 (“Yuasa”), 1:30-49. In ’198 Patent Fig. 11 below, the ferromagnetic electrodes 501 and 505 are alloys of cobalt (Co), iron (Fe), and boron (B)—labelled CoFeB—and the barrier layer 503 is magnesium oxide (“MgO”). The “(001)” in Fig. 11 is conventional notation indicating the orientation of the crystalline MgO layer.² EX2001 (“Kittel”), 14-15. Current flows through an MTJ device—e.g., between electrodes—using a quantum mechanical phenomenon called “tunnelling” that is discussed in more detail below. EX2002 (“Duke”), 1.

² “(001)” identifies a type of crystal plane orientation discussed *infra* §III.A.



The ferromagnetic electrodes are highly susceptible to magnetization.

EX2003 (“Oxford English Reference Dictionary”), 513 (definition of “ferromagnetism”). When an MTJ electrode is subjected to an applied magnetic field, the electrode magnetization may be aligned with the applied magnetic field. EX2004, (“Britannica”), 748-49. Arrows in ’198 Patent Figures 8(A)-8(B), annotated below, show the magnetization direction in each electrode. An MTJ device is in a “parallel” state when its electrodes have the same magnetization (Fig. 8(A)) and in an “antiparallel” state when its electrode magnetizations point in different directions (Fig. 8(B)). EX1009, 1:51-67.



The MTJ device’s resistance to current flow through the device depends on the electrode magnetization, making the MTJ device a magnetoresistive device.

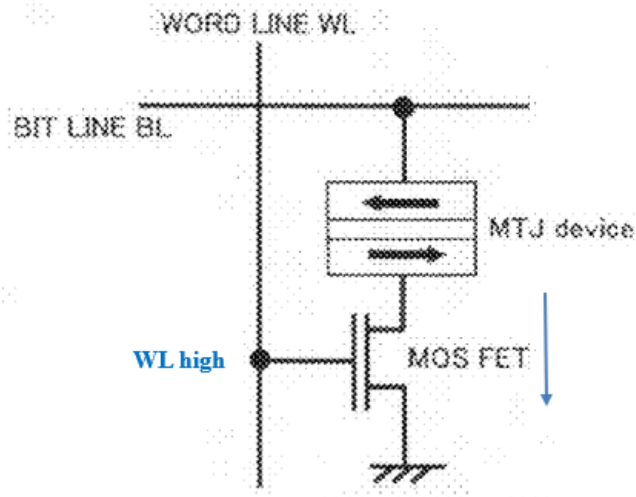
EX1009, 1:51-67. The resistance R_{ap} in the antiparallel state is *higher* than the resistance R_p in the parallel state. *Id.* By applying appropriate magnetic fields, an MTJ device can be configured in its parallel or antiparallel state. EX1062, 1:40-56. An MTJ device is thus a form of programmable resistor because its resistance can be changed by changing the relative magnetization of its electrodes.

B. Use in Non-Volatile Storage Devices

While an MTJ device has many applications, one use is in persistent non-volatile storage devices (*i.e.*, storage that retains data when power is turned off) like a solid-state memory or hard drive.

A solid-state memory can be formed with an array of memory cells that each includes an MTJ device that can store a bit of data. EX1009, 1:30-2:28. The two resistive states of an MTJ device (the parallel low resistance state and the non-parallel high resistance state) can encode a stored bit value as a binary “0” or “1,” respectively. EX1009, 1:51-67 (“information ‘1’ or ‘0’ can be stored depending on whether the [MTJ] resistance value is high or not”), 2:11-12 (“[s]tored information can be read by reading the resistance value of the MTJ device”). The MTJ device in a memory cell can be a resistive load for a type of transistor referred to as a metal-oxide-semiconductor field effect transistor (“MOSFET”). EX1009, Figs. 9(B) (annotated below), 9(C); 2:11-13.

antiparallel



A magnetoresistive random access memory (“MRAM”) is a large-scale non-volatile memory device consisting of an array of WORD LINES (“WLs”) and BIT LINES (“BLs”) disposed in an intersecting manner, with an MRAM cell disposed at each intersection. EX1009, 1:35-41, 1:51-53, Fig. 9(A). When the WL in a MRAM cell is driven high (“WL high”) the MOSFET turns on and current (blue arrow) flows through the MOSFET and the MTJ device on the BL, as illustrated above. This allows the resistance of the MTJ device to be read from the BL.

EX1009, 2:8-15. Because the MTJ device has a relatively high resistance R_{ap} in its *antiparallel* state compared to when the MTJ device is in its *parallel* state with relatively low resistance R_p , whether a “0” or “1” is stored in the MTJ memory cell can be determined by assessing whether the resistance value read on the BIT LINE is relatively high or low. *Id.*, 1:51-67; 2:8-15.

An MTJ device can alternatively be used as a read-out sensor for a magnetic disk drive that stores data using different magnetization states on a disk to encode binary “0s” and “1s.” EX1027 (“Nagahama”), [0082]; EX2005 (“Zhu”), 41, Fig. 12. In the read-out sensor, one of the MTJ’s electrodes has fixed magnetization while the other electrode’s magnetization is not fixed and therefore is sometimes called a “free layer”. EX2005, 41, Fig. 12. When the read-out sensor is brought into proximity with a location on the disk that stores a data bit using magnetization, the read-out sensor’s non-fixed MTJ electrode is impacted by the magnetic field of the stored data bit. *Id.* The read-out sensor’s MTJ thus adopts its parallel magnetization state (*e.g.*, when the stored data is a “1”) or its non-parallel magnetization state (*e.g.*, when the stored data is a “0”) depending on the stored data bit’s value. *Id.* When the read-out sensor pulls current through the MTJ to read the stored data bit value, the magnitude of the voltage across the MTJ’s electrodes indicates whether the MTJ is in its low resistive parallel state or its high resistive non-parallel state, and thereby indicates whether the stored data being read is a “1” or a “0.” *Id.*

C. “Magnetoresistance Ratio” and “Tunneling Magnetoresistance Ratio” (TMR) Describe the Same Parameter

For both above-described exemplary use cases, it is desirable to increase the difference between the MTJ’s parallel (R_p) and antiparallel (R_{ap}) resistances. EX1009, 2:34-59. For the same current passing through the MTJ device when a

stored data value is read, a greater difference between R_p and R_{ap} provides a larger difference between the read-out voltages representing a “1” and “0,” respectively. *Id.*, 4:62-5:3; 8:31-36. This reduces read-out errors by making it easier to distinguish between the voltages reflecting stored “1s” and stored “0s.” *Id.*, 2:49-55.

A parameter the ’198 Patent calls the “magnetoresistance ratio” (“MR ratio”) quantifies the difference between the MTJ device’s magnetoresistance in its antiparallel and parallel states. *Id.*, 4:64-5:3. The ’198 Patent represents this ratio as follows:

$$\text{MR ratio} = (R_{ap} - R_p) / R_p.$$

Id.

The MR ratio is thus the difference between the MTJ device’s magnetoresistance in its antiparallel and parallel states, normalized by the resistance in the parallel state. A relatively larger MR ratio corresponds to a larger proportional difference between the antiparallel resistance R_{ap} and parallel resistance R_p .

The MTJ device parameter the ’198 Patent calls the MR ratio is called the “tunnel magnetoresistance ratio” (“TMR”) in the Petition and is represented using the same formula reproduced below. Petition, 7 (“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 . . . Thus, high antiparallel resistance R_{ap} compared to lower parallel resistance R_p results in high TMR”).

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

Id., 7.

Patent Owner primarily uses Petitioner’s TMR terminology herein so the parties refer to the same parameter using the same terminology.

III. THE ’198 PATENT

A. Disclosed Embodiments

Dr. Shinji Yuasa, the ’198 Patent inventor, discovered how to make an MTJ device with an increased TMR. EX1009, 8:4-11 (an MTJ device produced using the inventive method achieved “the highest MR ratios that have so far been obtained at room temperature”).

Prior art MTJ devices used an amorphous material (aluminum oxide) as the tunnel barrier layer, meaning that the atoms in the tunnel barrier layer lacked an ordered arrangement. EX1009, 5:26-34. Dr. Yuasa determined that a barrier layer with a particular ordered arrangement would experience less scattering and that the “coherent states of electrons” would be conserved “during the tunneling process” through the barrier. *Id.*, 5:33-34. Dr. Yuasa determined that this could be achieved

by using a barrier layer comprising single-crystal magnesium oxide (MgO) (001) or poly-crystalline (*i.e.*, made up of multiple crystals) MgO with the (001) crystal plane preferentially oriented. *Id.*, 5:29-6:6.

In a cubic crystal the sides of the cubic structure are in—or parallel to—planes, like the top face of the cube which is in the (001) plane as shown in the annotated figure below. EX2001, 14-15, Fig. 16. The (001) notation means that a crystalline structure, *e.g.*, crystalline MgO(001), is oriented on the (001) plane.

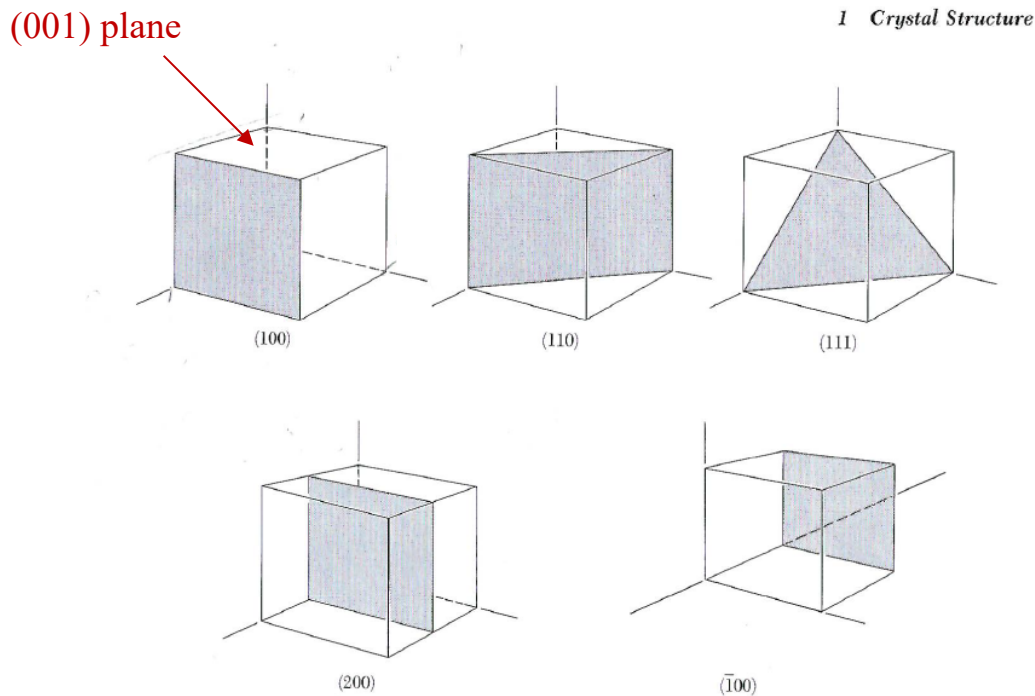
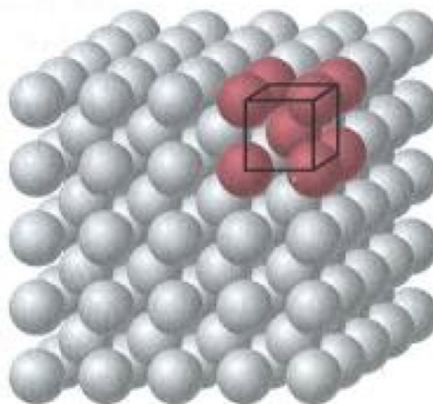
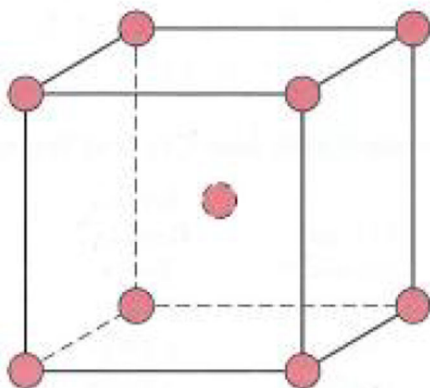


Figure 16 Indices of important planes in a cubic crystal. The plane (200) is parallel to (100) and to $(\bar{1}00)$.

One specific type of crystalline structure is a body-centered cubic (“BCC”) structure. BCC is a particular crystalline arrangement of atoms. EX2001, 13, 23, Figs. 11-12 (Table 3 showing most common crystal structures by element). As

shown below a BCC crystalline structure has atoms located at the center (dashed circle in center in figure on left below) and each corner (solid) of a cubic lattice, which repeats throughout the crystal. EX2009 (“Callister”), 36-37.



In one embodiment, Dr. Yuasa created an MTJ device with electrodes formed from a CoFeB alloy having a BCC crystalline structure sandwiching a single-crystalline MgO(001) layer. EX1009, 9:6-27; 5:39-6:34. Oxygen vacancies were formed in the MgO barrier layer during the fabrication process. *Id.*, 6:67-7:26. An oxygen vacancy refers to the absence of an oxygen atom where one is expected in a crystalline MgO structure. EX1037 (“Castanier”), 1, 3, Fig. 1. Because of the oxygen vacancies, the MgO crystal did not have a 1:1 ratio by atom of magnesium to oxygen. Instead, it was an MgO_x structure where “x” represents the number of oxygen atoms per magnesium atom, and where “x” was a value less than 1. EX1009, 7:7-11, 7:22-24 (“The value of x in MgO_x *due to oxygen vacancy defects* is such that $0.98 < x < 1$, and more preferably $0.99 < x < 1$.”).

Dr. Yuasa noted that an MTJ device having an MgO_x crystalline or polycrystalline structure in which “x” was less than 1 had a lower barrier height than if a perfect single-crystal MgO barrier layer had been used.³ EX1009, 3:12-16 (“the *height of the tunnel barrier . . . is smaller* than an ideal value of a perfect single-crystal without defect”). The specification refers to work that had been done by Wulfhekel (EX2006). *Id.*, 4:53-61. Wulfhekel used ultraviolet photoemission spectroscopy to identify an MgO crystal that was as perfect as could be made “with hardly any oxygen vacancy defect or lattice defect.” *Id.* Wulfhekel determined that this perfect MgO layer had a barrier height of 3.6 eV. EX2006 (“Wulfhekel”), 509; *see also* EX1009, 7:14-16. The ’198 Patent refers to this as the “ideal value” for the barrier height of an MgO barrier layer because Dr. Yuasa noted that any defects in an MgO barrier layer would reduce its barrier height, *e.g.*, Wulfhekel’s ideal value of 3.6 eV represented an upper limit on the potential barrier height for an MgO barrier layer. EX1009, 4:53-61, 7:14-16.

Dr. Yuasa determined that making an MTJ device so that its electrodes had a crystalline structure, and its MgO barrier layer had oxygen defects so it was not a

³ In conventional notation, “MgO” (*i.e.*, where no x appears) indicates a 1:1 ratio of magnesium and oxygen by atom. EX1009, 6:27-29.

defect-free crystal, resulted in a tunnel barrier height of 0.10 to 0.85 eV—smaller than the 3.6 eV barrier height for an ideal MgO barrier layer. EX1009, 7:7-11.

Dr. Yuasa estimated the tunnel barrier height in his MTJ device by fitting electrical conductance characteristics (*i.e.*, current-voltage (“I-V”) curves) of the MTJ device to the known Simmons formula. EX1009, 7:27-8:3. Simmons’ formula was the accepted technique for determining the tunnel barrier height for a tunneling device, *e.g.*, where current flowed due to the quantum mechanical phenomenon known as tunneling, which is described *supra* §II.A.

Dr. Yuasa discovered that his MTJ devices with crystalline electrodes, and a crystalline MgO barrier layer with oxygen vacancies, had ***increased*** TMR as compared to conventional MTJ devices. EX1009, 3:17-20 (“[t]hese features ***increase the magnetoresistance***”). As discussed *supra* §§II.B-II.C, when the MTJ is used in a memory cell, increased TMR improves the read-out accuracy for a stored data bit by increasing the differentiation between the voltages that represent stored “0s” and “1s.” EX1009, 3:17-20, Figs. 9(B), 9(C), 10 (“characteristics required for G bit-MRAM”).

B. Challenged Claims

The Petition challenges claims 1-6 (“Challenged Claims”). Claim 1 is independent and claims 2-6 depend directly or indirectly therefrom. Claim 1 recites, *inter alia*, a tunnel barrier layer disposed between first and second

ferromagnetic layers, “wherein the first ferromagnetic layer is composed of an Fe-Co alloy of BCC which alloy comprises Fe, Co and B.” Limitations 1[pre] and 1[b].⁴ A POSA understood that “BCC” means “body-centered cubic lattice structure” and refers to “the crystalline structure of [the] ferromagnetic electrode layer.” EX1009, 4:44-53; EX2001, 13, 23, Figs. 11-12, Table 3.

IV. PERSON OF ORDINARY SKILL IN THE ART (“POSA”)

For purposes of this Preliminary Patent Owner Response only, Patent Owner does not challenge Petitioner’s POSA definition (Petition, 28-29) because the Petition fails even if Petitioner’s POSA definition is adopted.

V. THE PETITION’S GROUNDS FAIL

A. Ground 1 (Bowen-Sunai) Fails For Multiple Independent Reasons

1. Ground 1 Fails Because the Petition’s Assertion that a POSA Had Reason to Combine Bowen and Sunai to Achieve a BCC Crystalline CoFeB Structure Is Unsupported

Petitioner contends that claim 1 “would have been obvious over Bowen in view of Sunai.” Petition, 29. Because Ground 1 relies on obviousness, Petitioner bears the burden to identify a “reason to combine the known elements *in the fashion claimed* by the patent at issue.” *KSR Int’l v. Teleflex*, 550 U.S. 398, 418

⁴ Patent Owner adopts Petitioner’s claim limitation labelling. Petition, xiv-xv (“List of Challenged Claims”).

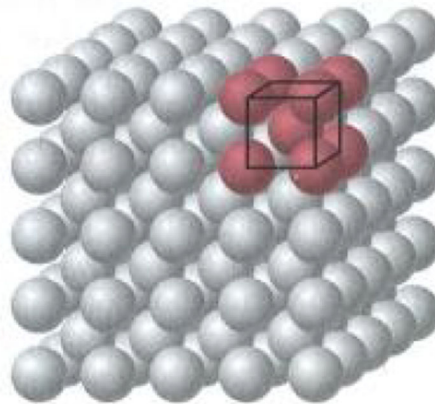
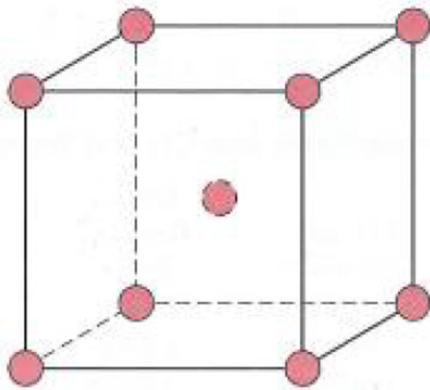
(2007). Petitioner’s alleged motivation to combine requires “articulated reasoning with some rational underpinning” and “cannot be sustained by mere conclusory statements[.]” *Id.*, quoting *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006).

As explained below, Petitioner’s alleged reason why a POSA would have purportedly combined Bowen and Sunai’s teachings “in the fashion claimed” by the ’198 Patent lack a rational underpinning. *KSR*, 550 U.S. at 418. Ground 1 fails for this independent reason.

a. Sunai Teaches Away From the Claimed Crystalline (BCC) Structure in the Ferromagnetic Layer

i. Limitation 1[b] Requires that the First Ferromagnetic Layer Have a Crystalline Structure

Limitation 1[b] requires that “the first ferromagnetic material layer is composed of an Fe—Co alloy of **BCC** which alloy comprises Fe, Co, and B.” BCC is a particular crystalline arrangement of atoms. EX2001, 13, 23, Figs. 11-12. As shown below, a crystalline BCC structure has an atom located at the center (dashed circle in center in figure on left below) and each corner (solid) of a cubic lattice, which repeats throughout the crystal. EX2009, 36-37.



ii. Sunai Teaches a Non-crystalline CoFeB Ferromagnetic Material Layer

Petitioner alleges that a POSA “would have found it obvious to replace Bowen’s first ferromagnetic material layer (Fe layer) with a CoFeB ferromagnetic layer as taught in Sunai to increase TMR” and thereby “produce [a] bcc CoFeB crystalline structure[.]” Petition, 33-35. This argument fails because Sunai *teaches away* from a ferromagnetic layer with the crystalline BCC structure recited in Limitation 1[b]. “[A] reference will teach away *if it suggests that the line of development flowing from the reference’s disclosure is unlikely to be productive of the result sought by the applicant.*” *In re Gurley*, 27 F.3d 551, 553 (Fed. Cir. 1994) (reference teaches away when a POSA “upon reading the reference . . . would be led in a direction divergent from the path that was taken by the applicant.”).

Sunai teaches that its CoFeB ferromagnetic layer is amorphous, meaning it is *not* crystalline. EX1030, [0024], [0025] (adding boron (“element Y”) inhibits

crystallization), [0030] (adding boron “suppress[es] crystallization”); EX2009, G1 (amorphous means “[h]aving a noncrystalline structure”). Indeed, the *only* evidence that Petitioner cites to support its assertion that “CoFeB was known to increase TMR compared to CoFe” unambiguously describes an *amorphous* CoFeB layer as providing this desired increase in TMR. Petition, 34 (citing EX1030, EX1055 (“Wang”), and EX1056 (“Hosomi”)); EX1030, [0025], [0030] (boron inhibits and suppresses crystallization); EX1055, 2269 (Abstract: “High-resolution transmission electron microscopy (HRTEM) reveals that *the CoFeB has an amorphous structure*”); EX1056, 1 (Abstract: “ferromagnetic layer . . . *has an amorphous structure containing a CoFeB or CoFeNiB alloy*”), [0039] (“an *amorphous layer comprised of CoFeB alloy*”).⁵

In fact, Sunai used boron in its film for the express purpose of making the film amorphous instead of crystalline. EX1030, [0025], [0030]. Sunai *discouraged* a crystalline structure because crystallization in the CoFeB film would have resulted in a ferromagnetic layer that “exhibits superparamagnetism, in which the

⁵ Petitioner cites EX1035 (“Moodera”) for the proposition that “CoFe was known to obtain better results than Fe[.]” Petition, 35. But EX1035 never describes boron or a CoFeB ferromagnetic layer.

magnetization direction fluctuates, resulting in a significantly *low* magnetoresistance change rate.” EX1030, [0030].

“Magnetoresistance change rate” in Sunai, (EX1030, [0030]) is the same MTJ device parameter that the Petition refers to as TMR. *See supra* §II.C (explaining “MR ratio” and demonstrating the Petition uses the term “TMR” to refer to “MR ratio”). U.S. Patent No. 6,590,803 (EX2010, “the ’803 Patent”) was filed by the same assignee, Toshiba, that filed EX1030 (Sunai), and lists the same co-inventor, Yoshiaki Saito, as listed in EX1030. The ’803 Patent expressly equates the rate of change in magnetoresistance with MR ratio. EX2010, 1:44-49 (“*the rate of change in the magnetoresistance (MR ratio)*”). Several other references corroborate this usage. U.S. Patent Application No. 2002/0036877 (EX2011) expressly defines MR ratio as the magnetoresistance change rate: “In each of these . . . TMR devices, *a magnetoresistance change rate (hereinafter, referred to as an ‘MR ratio’)* . . .” EX2011, [0060]. U.S. Patent No. 6,917,492 (EX2012), “the ’492 Patent”), equates the rate of change in magnetoresistance to MR ratio, explaining that “it is desirable to make *the rate of change in magnetoresistance (MR ratio)* of the magnetoresistive element as high as possible.” EX2012, 1:67-2:2. Thus, a POSA knew that “magnetoresistance change rate” meant TMR and, equivalently, MR ratio. Consequently, Sunai explains that

crystallization lowers the TMR compared to the TMR in the non-crystalline CoFeB layer. EX1030, [0030].

As discussed *supra* §§I.A.1, I.B.1, Petitioner acknowledges that it was generally desired to increase (not lower) TMR. Petition, 6-7. Indeed, the very reason Petitioner alleges that a POSA would have replaced Bowen’s ferromagnetic material layer with Sunai’s CoFeB layer was “to *increase* TMR.” Petition, 33.

Thus, Sunai teaches that its CoFeB layer was amorphous (not crystalline) because boron inhibited and suppressed crystallization (EX1030, [0024]-[0025], [0030]), and Sunai sought to avoid crystallization in the CoFeB layer because that would have undesirably resulted in “significantly lower” TMR (*id.*, [0030]). These teachings directly refute Petitioner’s assertion that Sunai would have motivated a POSA to modify Bowen to “increase TMR” (Petition, 33) by using a ferromagnetic layer with a crystalline “bcc CoFeB crystalline structure[.]” Petition, 35. Sunai is explicit that such crystallization would have had the opposite effect and would have “significantly lower[ed]” TMR. EX1030, [0030].

If Petitioner were correct that using Sunai’s CoFeB layer in Bowen would have necessarily “produced [a] bcc CoFeB crystalline structure[.]” (Petition, 35), then a POSA never would have been motivated to make this combination for the reason Petitioner alleges—“to increase TMR” (Petition, 33)—because the evidence is clear that increased TMR resulted from an amorphous (*i.e.*, non-crystalline) CoFeB

layer and Sunai expressly teaches that having a crystalline structure would have “significantly lower[ed]” TMR. EX1030, [0024]-[0025], [0030]; *see also*, EX1056, [0067]-[0068] (“by virtue of containing a ferromagnetic material having an **amorphous** structure, the element can realize improvement of the spin polarizability, namely, improvement of the TMR ratio”).

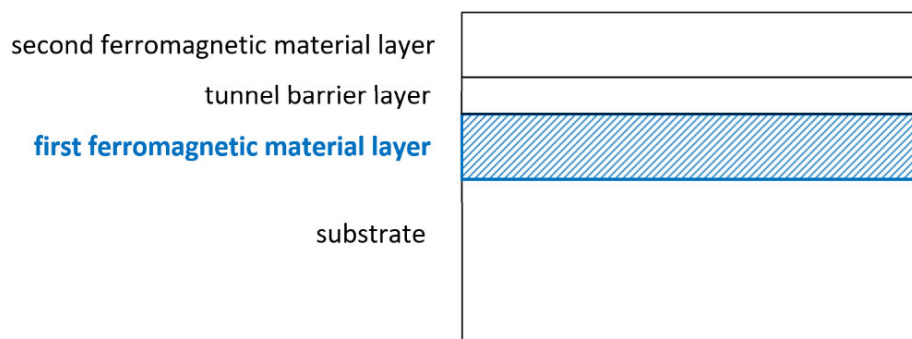
Sunai’s teachings (*see e.g.*, EX1030, [0024]-[0025], [0030]) would have led a POSA “in a direction divergent” from forming a ferromagnetic material layer with a crystalline structure, let alone a BCC crystalline structure as claimed. *Gurley*, 27 F.3d at 553. Sunai’s CoFeB layer was amorphous (*i.e.*, not crystalline) because boron inhibited and suppressed crystallization. EX1030, [0024]-[0025], [0030]. Sunai specifically used an amorphous CoFeB ferromagnetic layer because crystallization in the CoFeB layer would have “significantly lower[ed]” TMR. EX1030, [0030]. These teachings directly refute Petitioner’s assertion that Sunai would have motivated a POSA to modify Bowen to “**increase** TMR” (Petition, 33) by using a ferromagnetic layer with a crystalline “bcc CoFeB structure” (Petition, 35). Thus, the **sole** reason the Petition advances for why a POSA would have combined Bowen and Sunai fails to support Petitioner’s assertion that the resulting combination would have had a crystalline “bcc CoFeB structure” as Petitioner alleges to meet Limitation 1[b]. Petition, 35. Ground 1 fails for this independent reason.

* * *

Moreover, even if Petitioner’s suggestion that the alleged combination would convert Sunai’s amorphous CoFeB ferromagnetic material layer to a crystalline layer were correct (it is not), then as explained below (*infra* §§V.A.2.b-c) that result would squarely contradict Sunai’s teachings that the CoFeB layer should be amorphous. That result only underscores the incompatibility of Sunai and the claimed invention, further contradicting Petitioner’s alleged reasons to combine Bowen and Sunai.

2. Petitioner Fails to Establish that Its Bowen-Sunai Combination Has a Ferromagnetic Layer with a BCC CoFeB Structure as Alleged to Meet Limitation 1[b]

Claim 1 recites a “tunnel barrier layer disposed between a first ferromagnetic material layer and a second ferromagnetic material layer that are disposed over a substrate.” Limitation 1[pre].



Limitation 1[b] is directed to the “first ferromagnetic material layer.” The “first ferromagnetic material layer is located between the tunnel barrier layer and the substrate.” *See* Limitation 1[c].

Limitation 1[b] requires that “the first ferromagnetic layer is composed of an Fe-Co alloy of BCC which alloy comprises Fe, Co and B.” As discussed *supra* §III.A, “BCC” means “body-centered cubic lattice structure” and refers to “the crystalline structure of [the] ferromagnetic electrode layer.” EX1009, 4:44-47. *See supra* §III.A (explaining that BCC is a particular type of crystalline structure).

a. Petitioner Alleges that Limitation 1[b] is Met by a BCC Crystalline CoFeB Structure in the Bowen-Sunai Combination

The Petition alleges that “[c]laim 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.*” Petition, 32.

The Petition then alleges that Petitioner’s Bowen-Sunai combination meets Limitation 1[b] because that combination purportedly has “a bcc CoFeB structure.” Petition, 35. But as explained below, Petitioner’s evidence fails to support Petitioner’s assertion that its Bowen-Sunai combination has “a bcc CoFeB structure.” *Id.* That is fatal to Ground 1.

b. Sunai's CoFeB Ferromagnetic Layer Is not Crystalline and Petitioner Never Alleges that It Is

Petitioner alleges that a POSA would have “replace[d] Bowen’s first ferromagnetic layer (Fe layer) with a CoFeB ferromagnetic layer as taught by Sunai to increase TMR.” Petition, 33; *see also id.*, 34 (a POSA allegedly “would have been motivated to replace either or both of Bowen’s electrodes with CoFeB to increase TMR.”).

Even if Petitioner were correct that a POSA would have been motivated to replace Bowen’s first ferromagnetic layer with Sunai’s CoFeB ferromagnetic layer (which Patent Owner does not concede), Petitioner fails to establish that the resulting combination would have had “a bcc CoFeB structure” as Petitioner alleges to meet Limitation 1[b]. Petition, 35; *see also id.*, 32 (Limitation 1[b] is met by “any bcc CoFeB alloy”).

Sunai’s CoFeB ferromagnetic layer is *non-crystalline* and Petitioner never alleges otherwise. More specifically, Sunai’s ferromagnetic layer 4 is of composition represented as $(\text{CoFe})_{100-x}\text{Y}_x$, wherein Y is an element selected from a group that includes boron.⁶ EX1030, [0024]. Sunai teaches that boron inhibits and

⁶ The formula $(\text{CoFe})_{100-x}\text{Y}_x$ means that for every cobalt (Co) atom there are $(100-x)$ iron (Fe) atoms and x atoms of element Y, *e.g.*, boron (B). EX1030, [0024]. This

suppresses crystallization in the CoFeB ferromagnetic layer. EX1030, [0025] (“*crystallization is inhibited* according to the above material containing element Y”); [0030] (“addition of the element Y [*e.g.*, boron—see EX1030, [0024]] suppresses the diffusion or movement of atoms that reach the film formation surface during the film formation process, thereby *suppressing crystallization*. Conversely, if the element Y [*e.g.*, boron—see EX1030, [0024]] is not added, the atoms that reach the film formation surface diffuse or move more freely, making crystallization more likely to occur.”).

Because Sunai’s CoFeB ferromagnetic layer is not crystalline, it is not “a bcc CoFeB structure” (Petition, 32 and 35) because a “bcc . . . structure” is crystalline. *Supra* §III.A. Thus, even if a POSA would have been motivated to “replace Bowen’s first ferromagnetic layer (Fe layer) with a *CoFeB ferromagnetic layer as taught by Sunai*” (Petition, 33), that would not have yielded “a bcc CoFeB structure” as Petitioner alleges to meet Limitation 1[b] because Sunai’s CoFeB layer is not a crystalline structure, let alone “a *bcc* CoFeB structure.” Petition, 32 and 35.

is like H₂O nomenclature means that for every oxygen (O) atom there are 2 hydrogen (H) atoms.

c. Petitioner’s Assertion that Placing Sunai’s CoFeB Layer Adjacent to Bowen’s Crystalline MgO Layer Would Have Produced a BCC CoFeB Structure Fails

Petitioner does not allege that Sunai teaches that its CoFeB layer is a crystalline “bcc CoFeB structure” as alleged to meet Limitation 1[b]. Petition, 35. Instead, Petitioner alleges that if Sunai’s non-crystalline CoFeB layer had been used in Bowen’s device, it would have been converted into a crystalline “bcc CoFeB structure.” Petition, 35 (“it was known that use of CoFeB adjacent to crystalline MgO produced bcc CoFeB crystalline structures”).

While the Petition does not acknowledge it, Petitioner is advancing an inherency argument and fails to carry the high bar needed to establish inherency. *Guangdong Alison Hi-Tech Co. v. Int’l Trade Comm’n*, 936 F.3d 1353, 1364 (Fed. Cir. 2019) (“An element may be inherently disclosed only if it is ***necessarily present***, not merely probably or possibly present, in the prior art.”) (cleaned up and internal citations omitted); *PAR Pharm., Inc. v. TWI Pharms., Inc.*, 773 F.3d 1186, 1195 (Fed. Cir. 2014) (“inherency must be limited when applied to obviousness, and is present only when the limitation at issue is the ‘natural result’ of the combination of prior art elements”). Petitioner does not remotely carry that burden.

Petitioner does not allege that Bowen, Sunai or any other reference would have motivated a POSA to take some (unspecified) step or steps to ensure that the CoFeB layer in the Bowen-Sunai combination would have been “a ***bcc*** CoFeB

structure.” Petition, 35. Instead, Petitioner simply alleges that “a bcc CoFeB structure” would have been produced if Sunai’s CoFeB layer was used adjacent to Bowen’s crystalline MgO layer. *Id.* Petitioner does not even attempt to establish that it was impossible for Sunai’s CoFeB layer to have been used in Bowen without forming “a bcc CoFeB structure.” *Id.* Thus, Petitioner does not remotely establish that a bcc CoFeB structure would have **necessarily** resulted from using Sunai’s CoFeB layer in Bowen which is what would have been required to establish inherency. *Guangdong Alison Hi-Tech Co.*, 936 F.3d at 1364 (“An element may be inherently disclosed only if it is **necessarily present**, not merely probably or possibly present, in the prior art.”) (cleaned up and internal citations omitted).

Petitioner also ignores Sunai’s explicit teaching that a **crystalline** CoFeB structure in the ferromagnetic layer would have been undesirable. *See infra* §V.A.1.a.ii (explaining that a crystalline structure in the ferromagnetic CoFeB layer would have undesirably lowered the device’s TMR). Thus, a POSA motivated by Sunai to “replace Bowen’s first ferromagnetic layer (Fe layer) with a CoFeB ferromagnetic layer as taught by Sunai to increase TMR” (Petition, 33) would have been motivated to **avoid** a crystalline structure for the CoFeB layer. Petitioner cites no evidence establishing that a so-motivated POSA would have

been incapable of achieving an amorphous (non-crystalline) CoFeB layer as taught by Sunai.

None of the evidence Petitioner cites supports Petitioner's assertion that "it was known that use of CoFeB adjacent to crystalline MgO produced bcc CoFeB crystalline structures." Petition, 35. The Petition cites EX1060 ("Jimbo") at 310, EX1062 at 18:55-59, and the '198 Patent (EX1009) at 4:39-41 to purportedly support this assertion. *Id.* But as explained below, none of Petitioner's citations support its argument.

i. The '198 Patent does not support Petitioner's argument

Petitioner cites the '198 Patent at 4:39-41 for the proposition that "MgO (001), (100), (010) planes are the same." Petition, 35. This appears to be cited solely to demonstrate that an MgO layer can be crystalline. This provides no support for Petitioner's assertion that using a CoFeB layer adjacent to crystalline MgO would have "produced bcc CoFeB crystalline structures." *Id.*

ii. EX1060 does not support Petitioner's argument

Petitioner's reliance on EX1060 at 310 (cited at Petition, 35) is misplaced. EX1060 studied ***amorphous*** CoFeB deposited on silicon nitride (SiN). EX1060, 308-309. Indeed, the Title of EX1060 is "Thermal stability of spin valves using ***amorphous*** CoFeB." A POSA understood that "amorphous" means a structure that is ***not*** crystalline. EX2009, G1 (amorphous means "[h]aving a noncrystalline

structure”). Additionally, EX1060 does not even discuss MgO layers, let alone crystalline MgO layers. Finally, EX1060 makes no reference to the particular type of crystalline structure (BCC) recited in the claims.

EX1060 provides no support for Petitioner’s assertion that “us[ing] CoFeB adjacent to crystalline MgO produced bcc CoFeB crystalline structures.” Petition, 35.

iii. EX1062 does not support Petitioner’s argument

Petitioner cites EX1062 at 18:55-59 as “describing the effect of using CoFeB adjacent to MgO crystal structure[s].” Petition, 35. Petitioner then quotes from EX1062, but the quoted disclosure itself demonstrates that EX1062 does *not* support Petitioner’s argument because it describes a crystalline *CoFe* structure that has *no boron* and is not a “bcc CoFeB crystalline structure[.]” *Id.*

Petitioner quotes EX1062’s teaching that crystalline 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[.]” Petition, 35 (quoting EX1062, 18:55-59). Thus, EX1062 refers to a “bcc structure of CoFe”—not “a bcc CoFeB structure” as Petitioner alleges to meet Limitation 1[b]. Petition, 32 and 35. There is no boron in the crystalline “bcc structure of CoFe” that EX1062 describes.

The passage in EX1062 that Petitioner cites is describing a “storage layer 175 adjacent to the MgO tunnel barrier 120.” EX1062, 18:53. “The storage layer is comprised of an *amorphous* [i.e., non-crystalline] ferromagnetic layer 175” of CoFeB. *Id.*, 17:40-44. EX1062 teaches that only “a portion of the storage layer 175 adjacent to the MgO tunnel barrier . . . has crystallized” and that “the bulk of the storage layer 175 remains *amorphous* [non-crystalline].” *Id.*, 18:51-62. EX1062 teaches that there is no boron in the “thin crystalline ferromagnetic layer which has the bcc structure of CoFe.” *Id.*

Petitioner’s assertion that EX1062 teaches that “us[ing] CoFeB adjacent to crystalline MgO produced *bcc CoFeB structures*” (Petition, 35) is false because the “bcc structure of CoFe” in EX1062 has no boron (EX1062, 18:51-62) and is not a “bcc CoFeB structure” as Petitioner erroneously alleges (Petition, 35).

The reference to a crystalline structure forming of just CoFe (with no boron) is consistent with other teachings in EX1062 and in the art. For example, EX1062 describes another embodiment in FIG. 3B where a “thin interface layer 170 comprised of crystalline CoFe alloy” is formed between the MgO layer and the “amorphous ferromagnetic layer 175” of CoFeB. EX1062, 19:28-52. U.S. Patent Application No. 2014/0175428 (EX2013) explains that it was known that a thin crystalline CoFe layer—with no boron—can form out of an amorphous layer of CoFeB. EX2013, [0012], [0030]. And EX1062’s teaching that the thin crystalline

structure that is formed is “of CoFe”—without boron—is consistent with Sunai’s teaching that boron “inhibits” and “suppresses” crystallization. EX1030, [0024]-[0025], [0030].

As demonstrated above, it is clear from the quoted portion of EX1062 cited in the Petition that EX1062 provides no support for Petitioner’s assertion that using “CoFeB adjacent to crystalline MgO produced *bcc CoFeB crystalline structures*” nor that this would have happened in the Bowen-Sunai combination. Petition, 35.

d. Conclusion: Petitioner Fails to Establish that Its Bowen-Sunai Combination Would Have a BCC CoFeB Structure as Alleged to Meet Limitation 1[b]

The Petition alleges that “any bcc CoFeB alloy satisfies” Limitation 1[b] (Petition, 32) and that Petitioner’s Bowen-Sunai combination meets Limitation 1[b] because that combination purportedly has “a bcc CoFeB structure” (Petition, 35). But as explained above, Petitioner’s evidence fails to support Petitioner’s assertion that its Bowen-Sunai combination has “a bcc CoFeB structure.” *Id.* Ground 1 fails for this reason alone.

3. Ground 1’s Challenges to Claims 2-6 Fail Because They Inherit the Failures for Claim 1.

Claims 2-6 depend on claim 1. The Petition’s challenges to claims 2-6 thus fail for the same reasons that the Petitioner’s combination fails for Ground 1 with respect to claim 1 (*supra* §§V.A.1-2).

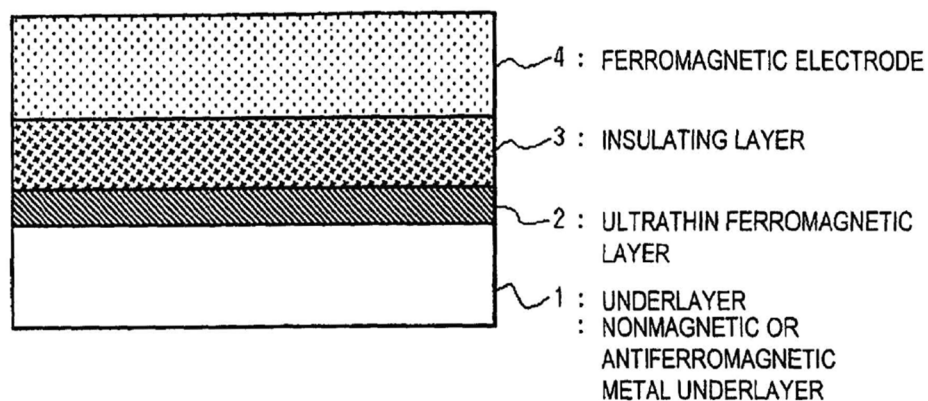
B. Ground 2 (Nagahama-Sunai) Fails

In Ground 2, Petitioner contends that claim 1 “would have been obvious over Nagahama in view of Sunai.” Petition, 47. Petitioner’s reasons to combine Nagahama with Sunai (*e.g.*, “Nagahama-Sunai”) fail for substantially the same reasons that Ground 1 fails.

1. Nagahama

Nagahama describes an MTJ comprising a tunnel barrier layer sandwiched between two ferromagnetic layers. EX1027, [0021]-[0022], Fig. 3. Like Bowen, Nagahama does not disclose a first ferromagnetic material layer comprising BCC crystalline CoFeB as required by Limitation 1[b].

FIG. 3



EX1027, Fig. 3 (cited at Petition, 49)

Nagahama describes providing a “larger magnetoresistive effect” in the MTJ by “varying only the thickness of a known material” layer “without changing the chemical composition of the material.” EX1027, [0015]. Nagahama provides this

result by, *inter alia*, controlling the thickness of a lower ferromagnetic material layer.

Specifically, Nagahama describes forming ferromagnetic layer 2 from iron (Fe). *Id.*, [0024]-[0025], [0028]-[0029]. Nagahama explains that for thin iron (Fe) ferromagnetic material layers, the magnetoresistance depends on the layer thickness. *Id.*, [0028], Fig. 4. Nagahama achieves “a large magnetoresistive effect” by making the ferromagnetic layer ultrathin, *e.g.*, setting the thickness of the ultrathin ferromagnetic layer 2 “in the range of 1 to 15 atomic layers.” *Id.*, [0022]-[0023], [0029] (“The magnetoresistive effect is substantially two times increased by setting the thickness of the Fe layer in the range of 4 to 10 atomic layers.”).

Nagahama describes using iron (Fe) (*e.g.*, *id.*, [0028], [0061]) and CoFe (*id.*, [0068]) for the ferromagnetic layer. Nagahama does not disclose using boron in the ferromagnetic layer.

2. Sunai Refutes Petitioner’s Unsupported Assertion that a POSA Would Have Used a *Crystalline* CoFeB Structure in Nagahama to Increase TMR

The Petition alleges that “[c]laim 1[b] 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.*” Petition, 51. The Petition then alleges that Petitioner’s Nagahama-Sunai combination meets Limitation 1[b] because that combination purportedly would have a CoFeB layer that has a “*body-centered*

cubic lattice’ as taught by Nagahama.” Petition, 53. But as explained below, Petitioner’s evidence fails to support Petitioner’s assertion that its Nagahama-Sunai combination has a BCC CoFeB layer. That is fatal to Ground 2.

As explained above, Sunai’s CoFeB layer is amorphous. *Supra* §V.A.1.a.ii; EX1030, [0024]-[0025], [0030]. Petitioner does not dispute that Sunai’s CoFeB layer lacks a crystalline structure. But Petitioner alleges that the Nagahama ferromagnetic layer—which is “replace[d]” in the Nagahama-Sunai combination—does have a crystalline BCC structure. Petition, 52-53. Petitioner alleges that “[d]espite replacing the material as recommended by Sunai, one of skill would have heeded Nagahama’s recommendation” that the ferromagnetic layer “remain” as “body-centered cubic lattice [i.e., BCC]” as taught by Nagahama. Petition, 53.

Petitioner asserts that its combination yields a BCC *crystalline* CoFeB layer rendering claim 1 obvious as a “combination of familiar elements.” *Id.*, 52. That is simply untrue. Petitioner presents no evidence of a BCC crystalline CoFeB structure. The hindsight in Petitioner’s rationale is apparent. Petitioner picks and chooses various aspects of the references—the CoFeB “material” from Sunai and the BCC crystalline structure from Nagahama—and alleges that a POSA would have put them together in a way not taught by either reference (or *any* evidence of record) to form a BCC *crystalline* CoFeB structure. The Petition’s own evidence lays bare that a POSA would have done no such thing.

As explained in connection with Ground 1 (*supra* §V.A.1.a.ii), Sunai specifically teaches that an amorphous (i.e., ***non-crystalline***) structure of its CoFeB layer is critical for producing the desired ***increase*** in TMR (Petition, 52) that Petitioner relies on to motivate its combinations because crystallinity in the CoFeB layer significantly ***lowered*** the TMR. EX1030, [0030].

Sunai thus directly refutes Petitioner’s assertion that a POSA would have used Sunai’s CoFeB “material” in Nagahama to increase TMR but would have formed a “body-centered cubic lattice” ***crystalline*** CoFeB structure. Petition, 53. A POSA would have done no such thing. Ground 2 fails for that reason alone.

3. Petitioner Fails to Establish that a POSA Would Have Had a Reasonable Expectation of Success in Forming the Nagahama-Sunai Combination to Have a *Crystalline* CoFeB Structure as Alleged to Meet Limitation 1[b]

Ground 2 also fails because Petitioner fails to establish that a POSA would have had a reasonable expectation of success in forming its Nagahama-Sunai combination to have a CoFeB layer with a BCC crystalline structure as alleged to meet Limitation 1[b]. Petition, 53.

It is black-letter law that establishing obviousness requires establishing a reasonable expectation of success in forming the combination alleged to meet the claim. *Regents of Univ. of California v. Broad Inst., Inc.*, 903 F.3d 1286, 1291 (Fed. Cir. 2018) (obviousness requires finding that POSA would have had a reasonable expectation of success in combining references to achieve the claimed

invention). Petitioner only alleges that it would have been “straightforward” and “predictable” to use Sunai’s CoFeB alloy to form the ferromagnetic electrodes of Nagahama’s MTJ device. Petition, 53. But Sunai teaches that its CoFeB layer is ***non-crystalline*** and that the presence of boron in the alloy inhibits and suppresses crystallinity. EX1030, [0024]-[0025], [0030].

While Petitioner alleges that a POSA had a reason to want to make Sunai’s CoFeB layer in a BCC crystalline structure, establishing a reasonable expectation of success is a separate, ***independent*** requirement in establishing obviousness. *Eli Lilly & Co. v. Teva Pharms. Int’l GmbH*, 8 F.4th 1331, 1344 (Fed. Cir. 2021) (“Before addressing Lilly’s specific arguments, however, we must first emphasize ***the clear distinction in our case law*** between a patent challenger’s burden to prove that a skilled artisan would have been motivated to combine prior art references ***and the additional requirement that the patent challenger also prove that the skilled artisan would have had a reasonable expectation of successfully achieving the claimed invention*** from the combination . . . A finding by the Board that a patent challenger has demonstrated a motivation to combine references does not necessarily imply that the challenger has also met its burden of showing a reasonable expectation of success in achieving a claimed method of treatment.”).

Petitioner ignores this requirement entirely. Indeed, the Petition never even alleges that a POSA would have reasonably expected to have succeeded in forming

a BCC *crystalline* CoFeB layer despite Sunai’s teaching that boron inhibits and suppresses crystallinity. Petition, 53; EX1030, [0024]-[0025], [0030].

Even if the Board were to read the Petition as alleging a reasonable expectation of success in forming a crystalline CoFeB layer (it did not), Petitioner presented no *evidence* establishing a reasonable expectation of success in forming a BCC *crystalline* CoFeB layer. While Petitioner relies on Nagahama claim 20 for the teaching that “ferromagnetic electrode layer is oriented in the (001) direction of a body-centered cubic lattice” (Petition, 53), that claim does not teach a BCC crystalline CoFeB ferromagnetic layer—or support a reasonable expectation of success in achieving one—because as explained above (*supra* §V.B.1) Nagahama only teaches a first or lower ferromagnetic layer made from iron (Fe) or CoFe, not one that includes boron. Thus, Nagahama does not meet Petitioner’s burden to show a reasonable expectation of success.

Ground 2 relies on the same Parkin reference (EX1062) that Ground 1 cited to purportedly teach what happens when a CoFeB layer is deposited atop a crystalline MgO layer. Petition, 53; *supra* §V.A.2.c.iii (discussing EX1062). But unlike its Ground 1 argument that quoted directly from EX1062 and thereby revealed that EX1062 teaches formation of a thin crystalline *CoFe* layer without boron (EX1062, 18:51-62), in Ground 2 the Petition simply mischaracterizes the reference as teaching a “bcc [crystalline] CoFeB electrode” where there is

allegedly boron in the crystalline structure. Petition, 53. EX1062 discloses no such thing. Petitioner does not cite a single piece of evidence that describes a BCC crystalline CoFeB structure.

Thus, the Petition asserts that its Nagahama-Sunai combination meets Limitation 1[b] because it has a “*body-centered cubic lattice*” crystalline CoFeB structure, but Petitioner fails to carry its burden to establish that a POSA would have reasonably expected success in forming such a structure. Petition, 53 (emphasis in original). Ground 2 fails for this additional reason.

4. Ground 2’s Challenges to Claims 2-6 Inherit the Failures for Claim 1.

Claims 2-6 depend on claim 1 and include Limitation 1[b]. The Petition’s challenges to claims 2-6 fail for the same reasons that the Petitioner’s combination fails for claim 1. *Supra* §§V.B.2-V.B.3.

VI. CONCLUSION

For at least the foregoing reasons the Petition fails to show a reasonable likelihood that a challenged claim is invalid. The Board should deny the Petition.

Respectfully submitted,
GODO KAISHA IP BRIDGE 1

Date: December 18, 2024

By: /Gerald B. Hrycyszyn/
Gerald B. Hrycyszyn, Reg. No. 50,474
Richard F. Giunta, Reg. No. 36,149
WOLF, GREENFIELD & SACKS, P.C.

VII. APPENDIX: U.S. PATENT NO. 9,608,198 CLAIM LIST

Ref	Limitation
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,
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[preamble]	The tunnel barrier layer according to claim 2,
3[a]	wherein the barrier height ϕ 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, Δs is an effective thickness of the tunnel barrier layer that is approximately equivalent to $(t_{\text{MgO}} - 0.5 \text{ nm})$, and t_{MgO} is an actual thickness of the tunnel barrier layer determined using a cross-sectional transmission electron microscope image.

Ref	Limitation
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.

CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24, the undersigned certifies that the foregoing **PATENT OWNER'S PRELIMINARY RESPONSE** contains 8,626 words excluding; a table of contents, a table of authorities, a certificate of service or word count, or appendix of exhibits or claim listing. Patent Owner has relied on the word count feature of the word processing system used to create this paper in making this certification.

Date: December 18, 2024

/Dara Del Rosario/
Dara Del Rosario
Paralegal
WOLF, GREENFIELD & SACKS, P.C.

CERTIFICATE OF SERVICE UNDER 37 C.F.R. § 42.6 (e)(4)

I certify that on December 18, 2024, I will cause a copy of the foregoing document, including any exhibits filed therewith, to be served via electronic mail, as previously consented to by Petitioner, upon the following:

Michelle E. Armond	michelle.armond@armondwilson.com
Douglas R. Wilson	doug.wilson@armondwilson.com
Joseph Li	josepher.li@armondwilson.com
Monica Arnold	monica.arnold@armondwilson.com
Yue Han	amy.han@armondwilson.com
	ipr@armondwilson.com

Date: December 18, 2024

/Dara Del Rosario/
Dara Del Rosario
Paralegal
WOLF, GREENFIELD & SACKS, P.C.