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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

WESTERN DIGITAL TECHNOLOGIES, INC.,
Petitioner,

v.

GODO KAISHA IP BRIDGE 1,
Patent Owner.

Case No. IPR2024-01493

Patent No. 10,680,167

PATENT OWNER'S PRELIMINARY RESPONSE

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<i>KSR Int’l v. Teleflex</i> , 550 U.S. 398 (2007)	18, 19
<i>Netflix, Inc. v. Realtime Adaptive Streaming LLC</i> , IPR2018-01227, Paper 39 (PTAB Jan. 14, 2020)	30

STATUTES

35 U.S.C. § 103	4, 29, 30
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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	RESERVED
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	RESERVED
2014	Definitions of “crystalline” and “crystallize,” Webster’s Encyclopedic Unabridged Dictionary of the English Language (1989)
2015	Definitions of “anneal”, “crystalline” and “crystallized,” Webster’s Ninth New Collegiate Dictionary (1984)
2016	Gleiter, H., <i>Nanostructured Materials: Basic Concepts and Microstructure</i> , Acta Materialia, Volume 48, Issue 1, pgs. 1-29 (January 2000)

I. INTRODUCTION

The claims of the challenged patent, U.S. Patent No. 10,680,167 (the “’167 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 ’167 Patent inventor Dr. Yuasa made a better MTJ device.

All 15 claims in the ’167 Patent require a magnesium oxide (MgO) layer disposed between “a first CoFeB layer” and “a second CoFeB layer,” and “annealing the first and second CoFeB layers and the [MgO layer].” Independent claim 1 and dependent claims 2-10 further require that “the first and second CoFeB layers are crystallized by the annealing” and that “the MgO layer is poly-crystalline.” Independent claim 11 and dependent claims 12-15 similarly require “annealing the first and second ferromagnetic layers . . . to crystallize the first and second CoFeB layers” and “forming . . . a magnesium oxide (MgO) layer to have a poly-crystalline state.” In the claims of the ’167 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.

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

A. Ground 1 (Bowen and Sunai or Parkin) 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 secondary references Sunai or Parkin to disclose an MTJ device with an electrode formed of a CoFeB alloy.

Petitioner alleges that a POSA would have “been motivated to substitute Sunai’s CoFeB electrode for either or both of Bowen’s electrodes to increase TMR, and lower H_f and H_c , of Bowen’s MTJ.” Petition, 23-24. Likewise, Petitioner alleges that a POSA would have made the same replacement based on Parkin. Petition, 27 (“As explained for Bowen and Sunai, one of skill would have been motivated to replace either or both of Bowen’s electrodes with CoFeB to increase TMR and lower H_f and H_c .”). TMR is a parameter of MTJ devices. Petitioner also alleges that in the resulting combination, “the first and second CoFeB layers are crystallized”, as required by the claims. Petition, 30-33, 47. Petitioner’s assertions are flatly contradicted by the very evidence the Petition relies on.

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

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.

Similarly, Parkin discloses that “high TMR [was] observed in [Parkin’s] devices and structures,” even though those structures “contain significant atomic disorder” or, in other words, are substantially amorphous. EX1062, 15:42-61.

Ground 1's assertion that Sunai or Parkin would have motivated a POSA to use a "crystallized" CoFeB structure (Petition, 31-33) in the substituted CoFeB layers of Bowen to increase TMR is unsupported and directly refuted by Sunai and Parkin. Ground 1 fails for that reason alone.

2. The Petition Fails to Show the Claim as a Whole Is Obvious

It is a claim "as a whole" that must be proven obvious (35 U.S.C. § 103), not a single limitation. The Petition focuses on importing from Sunai or Parkin a CoFeB ferromagnetic layer and to crystallize that CoFeB ferromagnetic layers through an annealing process. The Petition otherwise relies on Bowen to meet the other claimed limitations, including forming a polycrystalline MgO layer over the first CoFeB layer. Petition, 28-29, 33-35, 46. However, the Petition does not address whether the claimed MgO that is "poly-crystalline" and has "a (001) crystal plane ... preferentially oriented" as Bowen is alleged to disclose could be grown on the substituted CoFeB layer of Sunai or Parkin. Moreover, the Petition fails to address the very evidence submitted with the Petition. For example, Parkin teaches that annealing its CoFeB layer, which starts in an amorphous form like the CoFeB layer in Sunai (EX1062, 17:40-18:23, EX1030, [0024]-[0025], [0030]) would result in only a thin crystalline layer with the bulk of that CoFeB remaining amorphous after the anneal. EX1062, 18:59-62. Sunai reinforces that point by stating boron is intentionally added to the CoFe layer (to make it CoFeB) to *inhibit*

crystallization. EX1030, [0025], [0029]. And Wulff, a paper directed to the “characterization of MgO layers on different alumina and glass substrates,” states that “[i]f the arrangement of close neighbors is very loosely ordered, we have amorphous bodies.”. EX1036, 148. The Petition is silent on these issues.

The Petition thus fails to address whether the Bowen-Sunai combination or the Bowen-Parkin combination would meet the claim as a whole (in particular, whether the combination would have the claimed “poly-crystalline” MgO layer in which “a (001) crystal plane is preferentially oriented”, even if a POSA would have been motivated to substitute in CoFeB ferromagnetic layers, and even if a POSA would have been motivated to anneal those CoFeB ferromagnetic layers as the Petition argues.

B. Ground 2 (Nagahama and Sunai or Parkin) Fails

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

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 and Parkin references 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 “replace[d] Nagahama’s upper and lower ferromagnetic electrode

layers with Sunai's or Parkin's CoFeB layers" and "anneal the combination of Nagahama and Sunai or Parkin to crystallize the CoFeB layers" in order to "improve TMR, and lower H_f and H_c ." Petition, 56-57. As in Ground 1, Petitioner also alleges that the resulting combination meets Limitation 1[d] because it has a "***crystallized***" ***CoFeB structure*** after annealing. Petition, 56-57. As with Ground 1, 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 and Parkin

Petitioner does not dispute that Sunai's CoFeB layer does not have a crystalline structure. But, Petitioner alleges it was obvious to "anneal the combination of Nagahama and Sunai or Parkin to crystallize the CoFeB layers." Petition, 57.

Petitioner asserts that its combination that yields a ***crystalline*** CoFeB layer is obvious because "crystallizing CoFeB electrodes by annealing [was] known." Petition, 57. That is simply untrue.

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 upon which Petitioner relies to motivate its combinations because crystallinity in the CoFeB layer significantly ***lowered*** the

TMR. EX1030, [0030]. As discussed above, Parkin discloses that “high TMR [was] observed in [Parkin’s] devices and structures,” even though those structures “contain significant atomic disorder” or, in other words, are substantially amorphous. EX1062, 15:42-61.

Petitioner’s assertion that a POSA would have used Sunai’s or Parkin’s CoFeB in Nagahama to increase TMR but would have formed a *crystalline* CoFeB structure (Petition, 56-57) not taught by either reference is directly refuted by Sunai and Parkin. A POSA would have done no such thing. Ground 2 fails for that reason alone.

2. The Petition Fails to Show the Claim as a Whole Is Obvious

For the same reasons explained above with respect to Ground 1, the Petition for Ground 2 fails to address whether the Nagahama-Sunai combination or the Nagahama-Parkin combination would meet the claim as a whole (in particular, whether the combination would have the claimed MgO layer that is “poly-crystalline” and “in which a (001) crystal plan is preferentially oriented”), even if a POSA would have been motivated to substitute in CoFeB ferromagnetic layers, and even if a POSA would have been motivated to anneal those CoFeB ferromagnetic layers as the Petition argues.

C. The Petition’s Challenges to Claims 2-15 Fail for the Same Reasons

With respect to the other challenged independent claim (Claim 11), the Petition refers back to the arguments for Claim 1 and/or repeats the same arguments for replacing Bowen’s ferromagnetic layer with a crystallized CoFeB alloy that Petitioner alleges meets Limitation 11[d]. Accordingly, for the same reasons explained above with respect to Claim 1, both Grounds 1 and 2 fail with respect to independent Claim 11.

For dependent Claims 2-10 and 12-15, the Petition does not address any of the deficiencies noted above and therefore the Petition inherits the failures noted above with respect to independent claims.

* * *

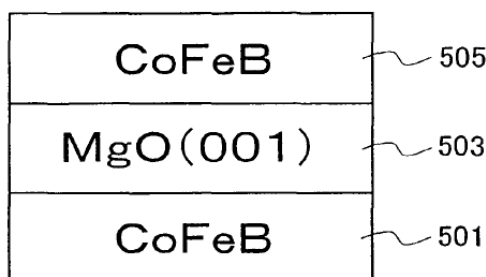
As detailed below, Petitioner fails to carry its burden to demonstrate that it is reasonably likely to prevail in demonstrating any challenged claim unpatentable. Institution should be denied.

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. EX1013 (“Yuasa”), 1:27-46. In ’167 Patent Fig. 11 below, the ferromagnetic electrodes 501 and 505 are alloys of cobalt (Co), iron

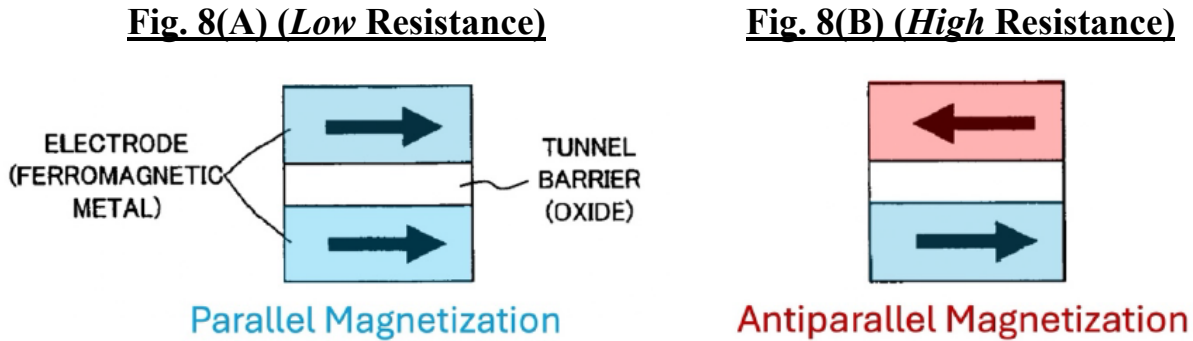
(Fe), and boron (B)—labelled CoFeB—and the barrier layer 503 is magnesium oxide (“MgO”). The “(001)” in Fig. 11 is conventional notation indicating the orientation of the crystalline MgO layer.¹ EX2001 (“Kittel”), 14-15. Current flows through an MTJ device—*e.g.*, between electrodes—using a quantum mechanical phenomenon called “tunnelling” that is discussed in more detail below. EX2002 (“Duke”), 1.



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”), 7:48-49. Arrows in ’167 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.

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

8(A)) and in an “antiparallel” state when its electrode magnetizations point in different directions (Fig. 8(B)). EX1013, 1:48-64.



The MTJ device’s resistance to current flow through the device depends on the electrode magnetization, making the MTJ device a magnetoresistive device. EX1013, 1:48-64. 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.

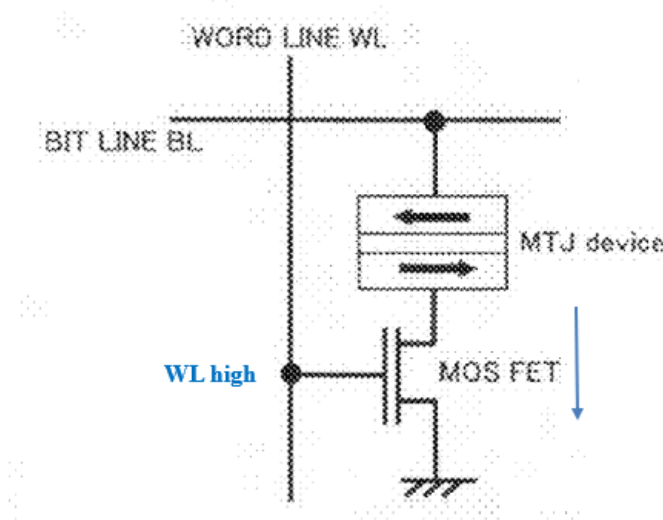
B. Use in Non-Volatile Storage Devices

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. EX1013, 1:27-2:26. 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. EX1013, 1:48-64 (“information ‘1’ or ‘0’ can be stored depending on whether the [MTJ] resistance value is high or not”), 2:8-9 (“[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”). EX1013, Figs. 9(B) (annotated below), 9(C); 2:8-10.

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. EX1013, 1:32-38, 1:48-51, 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.

EX1013, 2:5-12. 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.*, 1:42-64; 2:5-12.

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.

EX1013, 2:32-57. 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.*, 2:47-53.

A parameter the ’167 Patent calls the “magnetoresistance ratio” (“MR ratio”) quantifies the difference between the MTJ device’s magnetoresistance in its antiparallel and parallel states. *Id.*, 4:62-5:3. The ’167 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 '167 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, 6 (“Mathematically, TMR for an MTJ is equal to the difference in the resistance between the antiparallel (R_{ap}) and parallel states (R_p), divided by the parallel state resistance . . . Thus, high antiparallel resistance R_{ap} compared to lower parallel resistance R_p results in high TMR”).

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

Id., 6.

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

III. THE '167 PATENT

A. Disclosed Embodiments

Dr. Shinji Yuasa, the '167 Patent inventor, discovered how to make an MTJ device with an increased TMR. EX1013, 8:4-10 (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. EX1013, 5:25-33. 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.*, 5:32-33. 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.*, 5:28-6:5.

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.

(001) plane

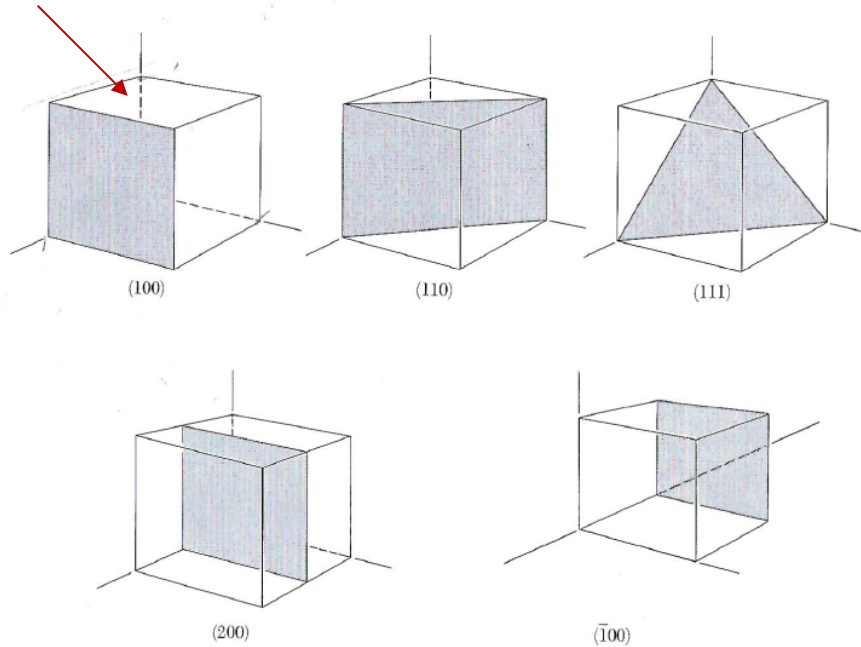
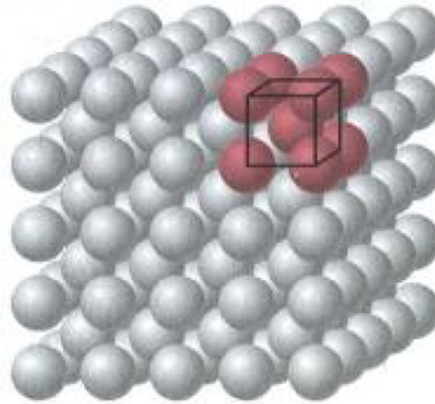
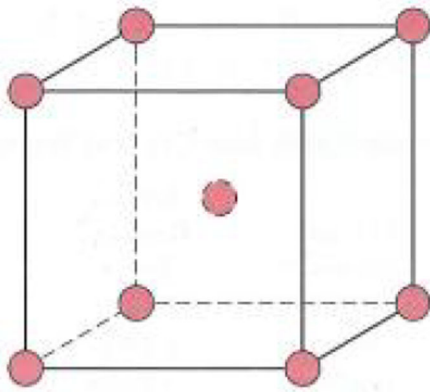


Figure 16 Indices of important planes in a cubic crystal. The plane (200) is parallel to (100) and to $\bar{1}00$.

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 crystalline structure sandwiching a single-crystalline MgO(001) layer. EX1013, 9:6-27, 5:38-6:33.

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.” EX1013, 3:15-18, Figs. 9(B), 9(C), 10 (“characteristics required for G bit-MRAM”).

B. Challenged Claims

All 15 claims in the '167 Patent require a magnesium oxide (MgO) layer disposed between “a first CoFeB layer” and “a second CoFeB layer,” and “annealing the first and second CoFeB layers and the [MgO layer].” Independent claim 1 and dependent claims 2-10 further require that “the first and second CoFeB layers are crystallized by the annealing” and that “the MgO layer is poly-

crystalline.” Independent claim 11 and dependent claims 12-15 similarly require “annealing the first and second ferromagnetic layers . . . to crystallize the first and second CoFeB layers” and “forming . . . a magnesium oxide (MgO) layer to have a poly-crystalline state.”²

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, 20) because the Petition fails even if Petitioner’s POSA definition is adopted.

V. THE PETITION’S GROUNDS FAIL

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

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

Petitioner contends that Claims 1 and 11 “would have been obvious over Bowen in view of Sunai or Parkin.” Petition, 20, 46. 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 (2007). Petitioner’s alleged motivation to combine

² Patent Owner adopts Petitioner’s claim limitation labelling. Petition, xvii-xix (“List of Challenged Claims”).

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 or Parkin’s teachings “in the fashion claimed” by the ’167 Patent lacks a rational underpinning. *KSR*, 550 U.S. at 418. Ground 1 fails for this independent reason.

- a. **Sunai Teaches Away From the Claimed Crystalline Structure in the Ferromagnetic Layer**
 - i. **Limitations 1[d] and 11[d] Require that the First and Second CoFeB Layers Are Crystallized by Annealing**

Limitation 1[d] requires “annealing the first and second CoFeB layers and the MgO layer, *wherein the first and second CoFeB layers are crystallized* by the annealing” and 11[d] requires “annealing the first and second ferromagnetic layers and the barrier layer, *to crystallize the first and second CoFeB layers.*” The reference to “crystallized” means that these layers assumes a crystalline form, or stated simply is crystalline. *See* EX2014, 351 (“crystalline ... 1. of or like crystal ... 2. formed by crystallization”; “crystallize ... 1. to form into crystals; cause to assume crystalline form”)); EX2015, 313 (“crystalline ... made of crystal : composed of crystals”; “crystallized ... formed into crystals”). The Petition also

uses crystalline and crystallized interchangeably. Petition, 30 (“Annealing...to crystallize”), 31 (“annealing ... result[ed] in ... crystalline” samples).

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

Petitioner alleges that a POSA “would have found it obvious to replace Bowen’s bottom Fe layer with an amorphous ferromagnetic CoFeB layer as taught by Sunai” (Petition, 23, 46) and also “to replace Bowen’s top FeCo electrode layer with an amorphous CoFeB layer from Sunai or Parkin” (Petition, 30, 47) and further that it would have been obvious “to crystallize” the CoFeB electrodes (Petition, 30, 47). This argument fails because Sunai *teaches away* from CoFeB layers with the crystalline structure recited in Limitations 1[d] and 11[d]. “[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 or is inapplicable to the structure in Bowen. Petition, 24-25 (citing EX1030, EX1035 (“Moodera”),³ EX1055 (“Wang”), EX1056 (“Hosomi”), and EX1061 (“Cardoso”)); 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 a CoFeB* alloy”); EX1061, 2273 (teaches it would be “unexpected” for CoFeB to be crystallized because “other groups obtained amorphous films when . . . Boron was incorporated.”).⁴

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*

³ Petitioner cites Moodera for the proposition that “CoFe was known to obtain better results than Fe[.]” Petition, 25. But Moodera never describes boron or a CoFeB ferromagnetic layer.

⁴ Moreover, a POSA would not look to Cardoso because the structure is entirely different from that of Bowen. *See infra* §V.A.1.a.ii(2).

a crystalline structure because crystallization in the CoFeB film would have resulted in a ferromagnetic layer that “exhibits superparamagnetism, in which the 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].

Petitioner acknowledges that it was generally desired to increase (not lower) TMR. Petition, 10. 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, 24.

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 low[er]” TMR (*id.*, [0030]). These teachings directly refute Petitioner’s assertion that Sunai would have motivated a POSA to modify Bowen to “increase TMR” (Petition, 24-25, *see also* Petition, 46) by using a ferromagnetic layer with Sunai’s CoFeB and “to crystallize” the CoFeB. Petition, 30, *see also* Petition, 47. Sunai is explicit that such crystallization would have had the opposite effect and would have “significantly low[ered]” TMR. EX1030, [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”). Thus, if, as Petitioner alleges, a POSA were

motivated to increase TMR and were following the teachings of Sunai to do so, (Petition, 24-25) then the POSA would have been motivated to *avoid* a crystalline structure for the CoFeB layer.

The Petition points to other evidence (EX1060, EX1061, EX1045) to support its alleged motivation to use a crystalline CoFeB layer in Bowen to meet Limitation 1[d], but that evidence similarly fails. Petition, 24-25, 28, 30-32. But each of EX1060, EX1061, and EX1045 are inapplicable to the Bowen combinations.

(1) EX1060

Contrary to Petitioner's assertion that EX1060 showed structures with crystalline CoFeB and improved TMR and other characteristics (Petition, 30-31), in fact, EX1060 does not disclose crystalline CoFeB as the Petition suggests. *See* EX1060, Title (“...*amorphous* CoFeB”).

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”).

Contrary to Petitioner's assertion that EX1060 shows crystalline CoFeB after annealing (Petition, 30-31), in fact, EX1060's XRD data shows peaks for

CoFe (*i.e.*, without boron). EX1060, 308 (“peak of CoFe fcc(111) appears after annealing”); Figs. 1 and 3 (identifying peaks for CoFe, among others, but no CoFeB). Thus, EX1060’s disclosure is consistent with the teaching in Sunai and Parkin that boron inhibits crystallization. *See* EX1030, [0025] (“crystallization is inhibited” in material containing boron), [0029]-[0030] (addition of boron “suppress[es] crystallization”); EX1062, 16:47-50 (“amorphous...CoFeB”), 19:25-27 (“[a] lowered boron content” is associated with “aid[ing] the formation of a thin crystalline CoFe interface layer”).

Thus, EX1060 would not motivate adoption of crystallized CoFeB as the Petition alleges to meet Limitation 1[d].

(2) EX1061

Similarly, EX1061 teaches it would be “unexpected” for CoFeB to be crystallized because “other groups obtained amorphous films when ... Boron was incorporated.” EX1061, 2273. Moreover, a POSA would understand that the results from EX1061 are not applicable in Petitioner’s proposed combination, and thus would not motivate the proposed modification, for at least the following reasons:

First, EX1061 teaches it would be “unexpected” for CoFeB to be crystallized because “other groups obtained amorphous films when ... Boron was incorporated.” EX1061, 2273.

Second, EX1061's CoFeB was positioned differently than it would have been in the Petitioner's proposed modification of Bowen, and differently than claimed. In EX1061, the CoFeB is surrounded by different layers with different material properties than would have been the case in Petitioner's Bowen-Sunai and Bowen-Parkin combinations. EX1061, 2272-73. Thus, the environment in which any anneal would be performed in the combinations would be different than that in EX1061. *Id.*

Finally, EX1061's CoFeB is made in a different way than in the primary references. *Compare* EX1061, 2272 ("The CoFeB films were prepared from a bulk target with nominal composition $\text{Co}_{73.8}\text{Fe}_{16.2}\text{B}_{10}$ (Co:Fe ratio of 82:18)") with EX1030, [0052] ("a ferromagnetic layer 4 consisting of $(\text{Co}_9\text{Fe})_{0.95}\text{B}_{0.5}$ having a thickness of 1.5 nm was deposited on the tunnel barrier layer 6 by performing sputtering..."), EX1062, 22:62-66 ("a layer 515 of CoFeB is deposited which is 60 Å thick. The composition of the layer as determined by RBS analysis is $\text{Co}_{57}\text{Fe}_{23}\text{B}_{20}$ (or $(\text{Co}_{60}\text{Fe}_{40})_{80}\text{B}_{20}$ where a sputtering target with a nominal composition of $\text{Co}_{59.5}\text{Fe}_{25.5}\text{B}_{15}$ was used)."). The Petition does not allege any further modification of Bowen that would have resulted in the annealing conditions of EX1061 being met, and does not establish with evidence that the conditions present in Bowen would have had the same result.

(3) EX1045

EX1045 is also irrelevant because, as Petitioner admits, it relates to crystallization of MgO and Fe structures, not CoFeB. Petition, 31-32 (citing EX1045 at 1, 6). Thus, EX1045 would not motivate a POSA to adopt CoFeB for the ferromagnetic layer of Bowen, let alone crystallized CoFeB as the Petition alleges to meet Limitation 1[d]. *Id.*

* * *

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 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 low[ered]" TMR. EX1030, [0030]. These teachings directly refute Petitioner's assertion that Sunai would have motivated a POSA to modify Bowen to "*increase* TMR" by "crystalliz[ing] the CoFeB layers." Petition, 31.

b. Petitioner's Motivation to Combine Bowen and Parkin Also Fails

Petitioner's alternative argument that Claim 1 would have been obvious over Bowen in view of Parkin is incorrect at least because it relies on the same deficient

reasoning that a POSA would have substituted a CoFeB material layer, this time from Parkin, into Bowen because it “improved [*i.e.*, increased] TMR.” Petition, 33. However, this motivation is not supported by the evidence of record for multiple independent reasons, as explained below.

First, as explained above, §V.A.1.a.ii, the evidence is clear that a POSA believed that amorphous (*i.e.*, non-crystalline) CoFeB layers resulted in increased TMR and that a crystalline structure would have “significantly low[ered]” TMR. EX1030, [0024]-[0025], [0030]; *see also*, EX1056, [0067]-[0068]. Although Petitioner’s combination of Bowen and Parkin does not expressly rely on Sunai, the Petition’s reliance on Sunai elsewhere in Ground 1 nonetheless makes the point, and Petitioner offers no explanation of why a POSA considering Bowen and Parkin would ignore Sunai’s teachings on this point.

Second, like Sunai, Parkin teaches that “high TMR [was] observed in [Parkin’s] devices and structures,” even though those structures “contain significant atomic disorder” or, in other words, are substantially amorphous. EX1062, 15:42-61, *see also* EX1062, 18:49-51 (“very high TMR values are unexpectedly found for MTJs with ... nominally amorphous storage layers”). Accordingly, Parkin would not motivate a POSA to pursue crystallized layers to increase TMR.

* * *

Thus, the *sole* reason the Petition advances for why a POSA would have combined Bowen and Sunai or Parkin, *i.e.*, to increase TMR, fails to support Petitioner's assertion that a POSA would have combined the references in a manner that would have had crystalline CoFeB as Petitioner alleges to meet Limitation 1[d]. Petition, 30-33. Ground 1 fails for this independent reason. Converting Sunai's or Parkin's amorphous CoFeB ferromagnetic material layer to a crystalline layer would squarely contradict Sunai's and Parkin's teachings that the CoFeB layer should be amorphous. *See supra* §V.A.1.b.

2. The Petition Fails to Show the Claim as a Whole Is Obvious

It is a claim "as a whole" that must be proven obvious (35 U.S.C. § 103), not a single limitation. The Petition focuses on importing from Sunai or Parkin CoFeB layers and crystallizing those CoFeB ferromagnetic layer through an annealing process. Petition, 30-33. The Petition otherwise relies on Bowen to meet the claimed limitations requiring an MgO layer located between the first and second CoFeB layers and wherein the MgO layer is "poly-crystalline" and "in which a (001) crystal plane is preferentially oriented." Petition, 28-29, 33-35, 46-47.

The Petition never addresses the impact of replacing Bowen’s Fe ferromagnetic layer with Sunai’s or Parkin’s CoFeB ferromagnetic layer on the remainder of Bowen’s structure and whether it would meet the claims as whole. Petition, 30-35. It is a claim “*as a whole*” that must be proven obvious (35 U.S.C. § 103), not a single limitation. *Gillette Co. v. S.C. Johnson & Son, Inc.*, 919 F.2d 720, 723-24 (Fed. Cir. 1990) (affirming nonobviousness: “Focusing on the obviousness of substitutions and differences, instead of on the invention as a whole, is a legally improper way to simplify the often difficult determination of obviousness.”). Petitioner’s obviousness argument does not even allege—let alone prove—the combination renders any challenged claim obvious *as a whole* and fails for that reason alone. *Infobionic v. Braemer*, IPR2016-01236, Paper 8, 12 (PTAB Dec. 23, 2016) (“[A] patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was known, independently, in the prior art.”); *Netflix, Inc. v. Realtime Adaptive Streaming LLC*, IPR2018-01227, Paper 39, 21-22 (PTAB Jan. 14, 2020) (finding no obviousness: “Petitioner does not argue or present any evidence directed to how or why the multiple embodiments of [a single prior art reference] would be combined.”).

Critically, the Petition does not address whether the claimed MgO layer that “is poly-crystalline in which a (001) crystal plane is preferentially oriented” as Bowen is alleged to disclose could be grown on the substituted CoFeB layer of Sunai or Parkin. Petition, 33-35. The Petition fails to address the very evidence submitted with the Petition. For example, Parkin teaches that annealing its CoFeB layer, which starts in an amorphous form like the CoFeB layer in Sunai (EX1062, 17:40-18:23, EX1030, [0024]-[0025], [0030]) would result in only a thin crystalline layer with the bulk of that CoFeB remaining amorphous after the anneal. EX1062, 18:59-62. Parkin also teaches that the portion of the CoFeB layer on which the MgO tunnel barrier in Bowen would need to be grown is the portion that remains amorphous because the boron diffuses into that region and inhibits crystallization. EX1062, 18:59-62, 19:19-22. As shown by the annotated version of Parkin’s FIG. 3A from the Petition (Petition, 26), Parkin’s layer 175 is amorphous in bulk with the possible exception of the interface with 120’. EX1062, 18:59-62.

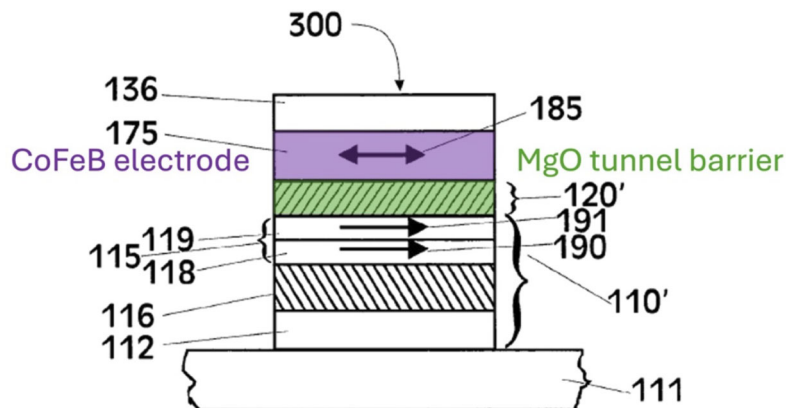


FIG. 3A

Sunai reinforces that point by stating boron is intentionally added to the CoFe layer (to make it CoFeB) to inhibit crystallization. EX1030, [0025], [0029]-[0030].

And Wulff states:

The purpose of this study is to prepare thin MgO films and characterize their structure and defect structure by non destructive x-ray methods. X-ray data are influenced by different types of lattice defects. The first type of imperfection, such as point defects, displacement disorders or substitution disorders, does not change the long-range order in the crystals. In the second type of imperfection *there is, on the contrary, no long-range order. If the arrangement of close neighbours is very loosely ordered, we have amorphous bodies.*

EX1036, 148.

The Petition is silent on these issues.

The Petition thus fails to address whether the Bowen-Sunai combination or the Bowen-Parkin combination would meet the claim as a whole (in particular, whether the combination would have the claimed “poly-crystalline” MgO layer, even if a POSA would have been motivated to substitute in a CoFeB ferromagnetic layer, and even if a POSA would have been motivated to anneal that CoFeB ferromagnetic layer as Petitioner alleges to meet Limitation 1[d].

3. Ground 1’s Challenges to Independent Claim 11 and Dependent Claims 2-10 and 12-15 Fail For the Same Reasons.

Similar to Claim 1, independent Claim 11 requires an MgO layer disposed between “a first CoFeB layer” and “a second CoFeB layer,” and “annealing the

first and second CoFeB layers and the [MgO layer].” Independent claim 11 also requires “annealing the first and second ferromagnetic layers . . . to crystallize the first and second CoFeB layers” and that “forming . . . a magnesium oxide (MgO) layer to have a poly-crystalline state.” With respect to Claim 11, the Petition refers back to the arguments for Claim 1. Petition, 46-47. Accordingly, for the same reasons explained above with respect to Claim 1, Ground 1 fails with respect to independent Claim 11. *See supra* §§V.A.1-V.A.2.

For dependent Claims 2-10 and 12-15, the Petition does not address any of the deficiencies noted above and therefore the Petition inherits the failures noted above with respect to independent Claim 1. *See supra* §§V.A.1-V.A.2.

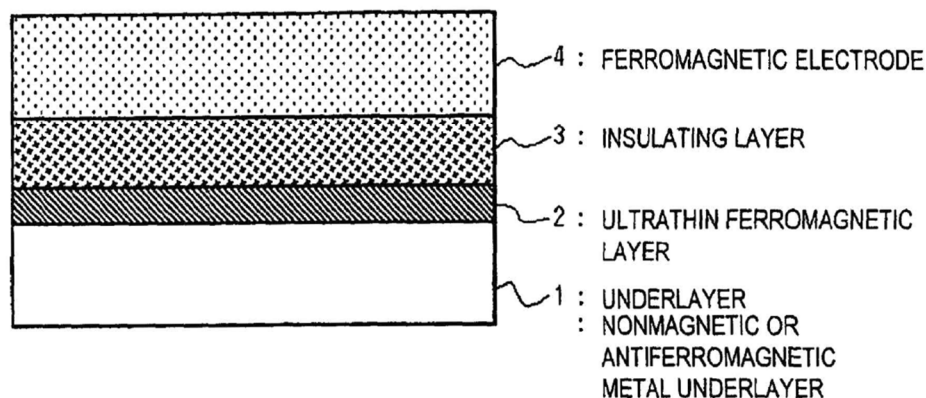
B. Ground 2 (Nagahama-Sunai or Nagahama-Parkin) Fails

In Ground 2, Petitioner contends that Claim 1 “would have been obvious over Nagahama in view of Sunai or Parkin.” Petition, 49. Petitioner’s reasons to combine Nagahama with Sunai or Parkin 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 crystalline CoFeB as required by Limitation 1[a] and 11[a].

FIG. 3



EX1027, Fig. 3 (cited at Petition, 51)

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. EX1027, [0023].

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 and Parkin Refute Petitioner’s Unsupported Assertion that a POSA Would Have Used a *Crystalline* CoFeB Structure in Nagahama to Increase TMR

The Petition alleges that “any CoFeB alloy satisfies” limitation 1[a]. Petition, 50. The Petition then alleges that Petitioner’s Nagahama-Sunai or Nagahama-Parkin combination meets Limitation 1[a], 1[c] and 1[d] because that combination purportedly would have “replace[d] Nagahama’s lower ferromagnetic electrode material with amorphous CoFeB as taught by Sunai” (Petition, 51), “replace[d] Nagahama’s upper ferromagnetic electrode layer with an amorphous CoFeB layer from Sunai or Parkin for the same reasons as explained for Claim 1[a]” (Petition, 56), and taught to “anneal” it (Petition, 57), or “[a]lternatively” with Parkin’s CoFeB layer (Petition, 53). But as explained below, Petitioner’s evidence fails to support Petitioner’s assertion that a POSA would have been motivated to substitute in CoFeB from Sunai or Parkin and crystallize those CoFeB layers through annealing as Petitioner alleges to meet Limitation 1[d]. 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 relies upon its arguments from Ground 1 to allege that "crystallizing CoFeB electrodes by annealing[] were known." Petition, 57.

Petitioner asserts that its combination would motivate a POSA to *crystallize* the CoFeB layers rendering Claim 1 obvious as a "combination of familiar elements." Petition, 52. That is simply untrue. Petitioner presents no evidence that a POSA would be motivated to substitute Sunai's or Parkin's CoFeB layer into Nagahama's structure and to crystallize through annealing the CoFeB layers as Petitioner alleges to meet Limitation 1[d].

The hindsight in Petitioner's rationale is apparent. Petitioner picks and chooses various aspects of the references—the CoFeB "material" from Sunai and Parkin and the crystalline structure from Nagahama—and alleges that a POSA would have put them together in a way not taught by either reference to form a *crystalline* CoFeB structure as Petitioner alleges to meet Limitation 1[d]. 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 that Petitioner relies on

(Petition, 51) to motivate its combinations because crystallinity in the CoFeB layer significantly **lowered** the TMR. EX1030, [0030].

As explained in connection with Ground 1 (*supra* § V.A.1.b), POSAs expected a crystalline structure to **lower** TMR (EX1030, [0024]-[0025], [0030]; *see also*, EX1056, [0067]-[0068]) and Parkin’s own structures with high TMR has “significant atomic disorder,” *i.e.*, were substantially amorphous. EX1062, 15:42-61; 18:49-51.⁵ Thus, Petitioner’s theory that a POSA would have been motivated to combine Parkin with Nagahama “to increase TMR” (Petition, 60) also fails.

Sunai and Parkin thus directly refute Petitioner’s assertion that a POSA would have used Sunai’s or Parkin’s CoFeB layers in Nagahama to increase TMR by forming a **crystallized** CoFeB layer as Petitioner alleges to meet Limitation

⁵ Ground 2 refers back to Ground 1 to supports its alleged motivation that a POSA would substitute in Sunai’s or Parkin’s CoFeB layer and crystallize them through annealing to increase TMR. Petition, 52 (“As explained in Ground 1, a skilled artisan knew that using CoFeB electrodes both improved TMR while lowering H_f and H_c .”); *see also* Petition, 56 (similar cross reference to Ground 1) Indeed, Ground 2 offers no support for this alleged motivation beyond what was provided for Ground 1. This alleged motivation thus fails for the same reasons detailed with respect to Ground 1.

1[d]. Petition, 56-57. A POSA would have done no such thing. Ground 2 fails for that reason alone.

3. The Petition Fails to Show the Claim As a Whole Is Obvious

It is a claim “as a whole” that must be proven obvious (35 U.S.C. § 103), not a single limitation. As with Ground 1, Ground 2 focuses on importing from Sunai or Parkin a CoFeB ferromagnetic layer as is or alternatively crystallizing that CoFeB ferromagnetic layer through an annealing process as Petitioner alleges to meet Limitation 1[d]. Petition, 56-57. The Petition otherwise relies on Nagahama to meet the other claimed limitations, including “forming a magnesium oxide (MgO) layer over the first CoFeB layer,” “wherein the MgO layer is poly-crystalline in which a (001) crystal plane is preferentially oriented.” Petition, 54-55, 57-58.

The Petition never addresses the impact of replacing Nagahama’s “(001)-highly-oriented lower ferromagnetic electrode layer” (EX1027, [0073] (cited in Petition, 51)) with Sunai’s or Parkin’s CoFeB ferromagnetic layer on the remainder of Nagahama’s structure and whether it would meet the claims as whole. Petition, 51-54. It is a claim “*as a whole*” that must be proven obvious (35 U.S.C. § 103), not a single limitation. *See supra* §V.A.3 (citing case law).

As with Ground 1, the Petition does not address whether the claimed MgO layer “wherein the MgO layer is poly-crystalline in which a (001) crystal plane is

preferentially oriented.” Petition, 54-55, 57-58. For the same reasons discussed with respect to Ground 1 (*see supra* § V.A.3), Ground 2 fails to address the very evidence relied on by the Petition.

The Petition thus fails to address whether the Nagahama-Sunai combination or the Nagahama-Parkin combination would meet the claim as a whole (in particular, whether the combination would have the claimed “poly-crystalline” MgO tunnel barrier layer), even if a POSA would have been motivated to substitute in a CoFeB ferromagnetic layer, and even if a POSA would have been motivated to anneal that CoFeB ferromagnetic layer as the Petition argues.

4. Ground 2’s Challenges to Independent Claim 11 and Dependent Claims 2-10 and 12-15 Fail For the Same Reasons.

Similar to Claim 1, independent Claim 11 requires an MgO layer disposed between “a first CoFeB layer” and “a second CoFeB layer,” and “annealing the first and second CoFeB layers and the [MgO layer].” Independent claim 11 also requires “annealing the first and second ferromagnetic layers . . . to crystallize the first and second CoFeB layers” and “forming . . . a magnesium oxide (MgO) layer to have a poly-crystalline state.” With respect to Claim 11, the Petition refers back to the arguments for Claim 1. Petition, 66-67. Accordingly, for the same reasons explained above with respect to Claim 1, Ground 2 fails with respect to independent Claim 11. *See supra* §§V.B.1-V.B.3.

For dependent Claims 2-10 and 12-15, the Ground 2 does not address any of the deficiencies noted above and therefore the Petition inherits the failures noted above with respect to independent Claim 1. See *supra* §§V.B.1-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: February 4, 2025

By: /Gerald B. Hrycyszyn/

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VII. APPENDIX: U.S. PATENT NO. 10,680,167 CLAIM LIST

Ref	Limitation
1[preamble]	A method of manufacturing a magnetic tunnel junction 55 (MTJ) device, comprising:
1[a]	forming a first CoFeB layer that is amorphous;
1[b]	forming a magnesium oxide (MgO) layer over the first CoFeB layer;
1[c]	forming a second CoFeB layer that is amorphous over the MgO layer; and
1[d]	annealing the first and second CoFeB layers and the MgO layer, wherein the first and second CoFeB layers are crystallized by the annealing, and
1[e]	wherein the MgO layer is poly-crystalline in which a (001) crystal plane is preferentially oriented.
2	The method of claim 1, wherein after the annealing, the first and second CoFeB layers are entirely crystallized.
3	The method of claim 1, wherein after the annealing, each of the first and second CoFeB layers is poly-crystalline in which a (001) crystal plane is preferentially oriented.
4[preamble]	The method of claim 1, wherein
4[a]	after the annealing, the first and second CoFeB layers are entirely crystallized, and
4[b]	each of the first and second CoFeB layers is polycrystalline in which a (001) crystal plane is preferentially oriented.
5	The method of claim 1, wherein after the annealing, each of the first and second CoFeB layers is poly-crystalline in which a (001) crystal plane is preferentially oriented and each of the first and second CoFeB layers includes a BCC (body-centered cubic) structure.

Ref	Limitation
6[preamble]	The method of claim 1, wherein
6[a]	after the annealing, the first and second CoFeB layers are entirely crystallized, and
6[b]	each of the first and second CoFeB layers is polycrystalline in which a (001) crystal plane is preferentially oriented and each of the first and second CoFeB layers includes a BCC (body-centered cubic) structure.
7	The method of claim 1, wherein in the forming the MgO layer, the MgO layer is formed as a MgO _x (0<x<1) layer.
8	The method of claim 1, wherein in the forming the MgO layer, the value of x in MgO _x for the MgO layer is greater than 0 and less than 1.
9	The method of claim 1, wherein in the forming the MgO layer, the MgO layer is formed directly on the first CoFeB layer.
10[preamble]	The method of claim 1, wherein:
10[a]	in the forming the MgO layer, the MgO layer is formed directly on the first CoFeB layer, and
10[b]	in the forming the second CoFeB layer, the second CoFeB layer is formed directly on the MgO layer.
11[preamble]	A method of manufacturing a magnetic tunnel junction (MTJ) device, comprising:
11[a]	forming a first ferromagnetic layer including a first CoFeB layer that is amorphous;
11[b]	forming a barrier layer including a magnesium oxide (MgO) layer to have a poly-crystalline state in which a (001) crystal plane is preferentially oriented over the first ferromagnetic layer;

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11[c]	forming a second ferromagnetic layer including a second CoFeB layer that is amorphous over the barrier layer; and
11[d]	annealing the first and second ferromagnetic layers and the barrier layer, to crystallize the first and second CoFeB layers.
12	The method of claim 11, wherein after the annealing, the first and second CoFeB layers are entirely crystallized.
13[preamble]	The method of claim 11, wherein
13[a]	after the annealing, the first and second CoFeB layers are entirely crystallized, and
13[b]	each of the first and second CoFeB layers is polycrystalline in which a (001) crystal plane is preferentially oriented and each of the first and second CoFeB layers includes a BCC (body-centered cubic) structure.
14	The method of claim 11, wherein in the forming the barrier layer, the MgO layer is formed as a MgO_x ($0 < x < 1$) layer.
15[preamble]	The method of claim 11, wherein:
15[a]	in the forming the barrier layer, the barrier layer is formed directly on the first ferromagnetic layer, and
15[b]	in the forming the second ferromagnetic layer, the second ferromagnetic layer is formed directly on the barrier 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 7,763 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: February 4, 2025

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

I certify that on February 4, 2025, 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:

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