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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. IPR2024-01447

Patent No. 8,405,134

PATENT OWNER'S PRELIMINARY RESPONSE

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STATUTES

35 U.S.C. § 103	6, 49, 60
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REGULATIONS

37 C.F.R § 42.104(4)	39
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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. 8,405,134 (the “’134 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 ’134 Patent inventor Dr. Yuasa made a better MTJ device.

All four claims in the ’134 Patent require a tunnel barrier layer disposed between first and second ferromagnetic material layers. The first ferromagnetic material layer is deposited on a substrate. Limitations in independent Claims 1 and 3 that the Petition labels as Limitation 1[e] and 3[e] require that the first ferromagnetic material layer is “crystallized and comprises CoFeB alloy.” In the claims of the ’134 Patent, “Fe” is iron, “Co” is cobalt, and “B” is boron. The ’134 Patent refers to an alloy of Co, Fe, and B 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 “replace[d] Bowen’s first ferromagnetic material layer (Fe layer) with a CoFeB ferromagnetic layer as taught by Sunai to increase TMR.” Petition, 35. Likewise, Petitioner alleges that a POSA would have made the same replacement based on Parkin. Petition, 39 (“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 the resulting combination would have had a ferromagnetic layer with a “crystallized ... CoFeB alloy” structure alleged to meet the above-discussed Limitations 1[e] and 3[e]. Petition, 38-40, 45-48. 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, 38-40) in the ferromagnetic layer of Bowen to increase TMR is unsupported and directly refuted by Sunai and Parkin. 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[e]

Ground 1 also fails because Petitioner fails to establish that its Bowen-Sunai combination would have had the "crystallized" CoFeB structure alleged to meet Limitation 1[e]. Petition, 38-40, 45-48. 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, 35. But Sunai's CoFeB layer is *non-crystalline* (amorphous), so replacing Bowen's ferromagnetic layer with Sunai's layer would have yielded a *non-crystalline* (amorphous) CoFeB layer—not a "crystallized" CoFeB structure as alleged to meet Limitation 1[e]. Petition, 38-40.

Despite Sunai's CoFeB layer being amorphous, Petitioner alleges that it would have been obvious to crystallize Sunai's CoFeB electrode and that it was known to crystallize CoFeB electrodes by annealing them. Petition, 37-38. Petitioner's allegation that this was known is not supported by Petitioner's evidence. For example, Parkin teaches that annealing a CoFeB layer positioned

above a crystallized MgO layer that acts as a template results in the formation of a thin crystalline layer, however, the remainder of the layer remains amorphous.

EX1062, 18:55-62. Thus, Petitioner's overly broad statement that "[a]nnealing CoFeB electrodes to crystallize them also was known" (Petition, 37) fails to account for the conditions required to achieve a crystal CoFeB layer by annealing and the requirements of the MTJ in the combination Petitioner is proposing.

Indeed, Petitioner never sets forth the conditions of the proposed annealing, and instead cites two references that describe different annealing procedures. Petitioner, 37 (citing EX1060, EX1061).

Finally, the Petition fails to establish evidence showing that the conditions required to achieve a crystal CoFeB layer in the proposed combination of Bowen and Sunai exist. *See infra* §V.A.2.c.ii.

3. Petitioner Fails to Establish that Its Bowen-Parkin Combination Would Have Resulted in a Ferromagnetic Layer with a Crystalline CoFeB Structure Meeting Claim 1

The "first ferromagnetic material layer" described above with respect to Limitation 1[e] has a specific structural position, as required by Claim 1. It must be deposited on a substrate (1[a]) and the claimed tunnel barrier layer is located between the first and second ferromagnetic material layers (1[c]). Petitioner's allegation that a POSA would have replaced Bowen's electrodes with *crystallized* CoFeB based on Parkin's layer 175 fails because Parkin states that its "layer 175

[is] *a thin crystalline ferromagnetic layer which has the bcc structure of CoFe* [not CoFeB, and] the bulk of the storage layer 175 remains amorphous.” EX1062, 18:49-60.¹

In addition, Parkin’s layer 175 is not positioned as required for the claimed first ferromagnetic material layer of Claim 1. The layer 175 is above the MgO tunnel barrier layer 120’. EX1062, 17:4, 17:21-44. Parkin’s FIG. 3A includes additional ferromagnetic layers 118 and 119, but notably neither one is made of CoFeB. EX1062, 13:11-13. Petitioner acknowledges as much, stating that “Parkin itself teaches that the top and bottom electrodes in Figure 3A may be ‘inverted.’” Petition, 40. But this is incorrect because Parkin refers to the functions of the layers, not the material. EX1062, 17:7-10, 22:29-33.

Accordingly, a POSA would not have replaced Bowen’s electrode with a CoFeB layer based on Parkin in a manner meeting the requirements of the claimed first ferromagnetic material layer.

4. 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 as is or alternatively crystallizing that CoFeB

¹ Emphasis added unless otherwise noted.

ferromagnetic layer through an annealing process (which, as discussed above, is not explained in any detail). The Petition otherwise relies on Bowen to meet the limitations requiring a “tunnel barrier layer located between the first and second ferromagnetic layers” and “wherein said tunnel barrier layer comprises a single-crystalline magnesium oxide . . . or a poly-crystalline magnesium oxide.” Petition, 31-33. However, the Petition does not address whether the claimed “single-crystalline magnesium oxide [or] poly-crystalline magnesium oxide” tunnel barrier layer 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 amorphous 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 “single-crystalline magnesium oxide [or] poly-crystalline magnesium oxide” 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.

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 lower ferromagnet electrode material with CoFeB as taught by Sunai to increase TMR and lower H_f and H_c ” or would have “looked to Parkin[.]” to “improv[e] the TMR.” Petition, 57, 60. As in Ground 1, Petitioner also alleges that the resulting combination meets Limitation 1[e] because

it has a “*crystalline*” *CoFeB structure* after annealing. Petition, 59. 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 that the Nagahama ferromagnetic layer—which is “replace[d]” in the Nagahama-Sunai and Nagahama-Parkin combinations—does have a crystalline structure. Petition, 57, 60. Petitioner also alleges it was obvious to “anneal Nagahama’s MTJ with CoFeB to obtain a crystalline ferromagnetic layer.” Petition, 59.

Petitioner asserts that its combination that yields a *crystalline* CoFeB layer is obvious because it is a “combination of familiar elements.” Petition, 58. That is simply untrue—Petitioner presents no evidence that introducing an amorphous layer from Sunai or Parkin into Nagahama would yield a 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 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 (or *any* evidence of record) to form a *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 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 “material” in Nagahama to increase TMR but would have formed a ***crystalline*** CoFeB structure (Petition, 59-60) 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. Petitioner Fails to Establish that a POSA Would Have Had a Reasonable Expectation of Success in Forming the Nagahama-Sunai or Nagahama-Parkin Combination to Have a *Crystalline* CoFeB Structure as Alleged to Meet Limitation 1[e]

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 or Nagahama-Parkin combination to have a CoFeB layer with a crystalline structure as alleged to meet Limitation 1[e]. Petition, 58-61.

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, 58-61. 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]. And as discussed above, Parkin’s layer 175 has a “***thin crystalline ferromagnetic layer which has the bcc structure of CoFe*** [***not CoFeB***, and] the bulk of the storage layer 175 remains amorphous.” EX1062, 18:49-60.

Further, Parkin’s layer 175 is not positioned as required by Claim 1 of the claimed first ferromagnetic material layer. The layer 175 is above the MgO tunnel barrier layer 120’. EX1062, 17:4, 17:21-44. Parkin’s Fig. 3A includes additional ferromagnetic layers 118 and 119, but notably neither one is made of CoFeB. EX1062, 13:11-13. Accordingly, a POSA would not have replaced Bowen’s electrode with a CoFeB layer based on Parkin in a manner meeting the requirements of the claimed first ferromagnetic material layer.

Petitioner also alleges that a POSA had a reason to want to make Sunai’s and Parkin’s CoFeB layer in a 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 *crystalline* CoFeB layer despite Sunai's teaching that boron inhibits and suppresses crystallinity and Parkin's teaching the crystalline layer that does form is CoFe, not CoFeB. Petition, 59-60.

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 *crystalline* CoFeB layer. None of Nagahama, Sunai, or Parkin describes a 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, 57. The Petition again mischaracterizes the reference as teaching "crystallized CoFeB" where there is boron in the crystalline structure. Petition, 60. EX1062 discloses no such thing.

Thus, the Petition asserts that its Nagahama-Sunai and Nagahama-Parkin combination meets Limitation 1[e] because it has a 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, 59-60. Ground 2 fails for this additional reason.

3. 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 “single-crystalline magnesium oxide [or] poly-crystalline magnesium oxide” 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.

C. The Petition’s Challenges to Claim 2-4 Fail for the Same Reasons

With respect to the other challenged independent claim (Claim 3), the Petition refers back to the arguments for Claim 1 and/or repeats the same arguments for replacing Bowen’s and Nagahama’s ferromagnetic layer with a crystallized CoFeB alloy. Accordingly, for the same reasons explained above with respect to Claim 1, both Grounds 1 and 2 fail with respect to independent Claim 3.

For dependent Claims 2 and 4, Grounds 1 and 2 do not address any of the deficiencies noted above and therefore the Petition inherits the failures noted above with respect to independent claims.

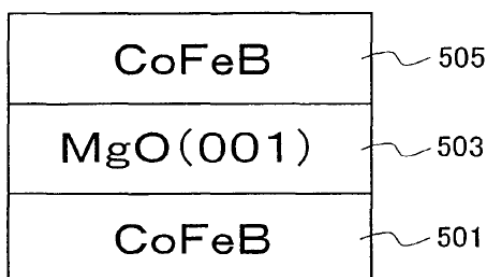
* * *

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

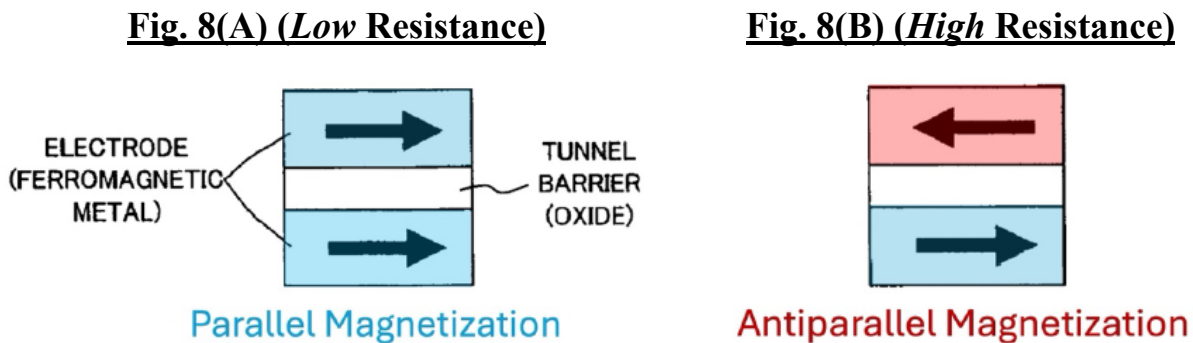
A. Overview

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. EX1005 (“Yuasa”), 1:23-42. In ’134 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 ’134 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)). EX1005, 1:44-59.



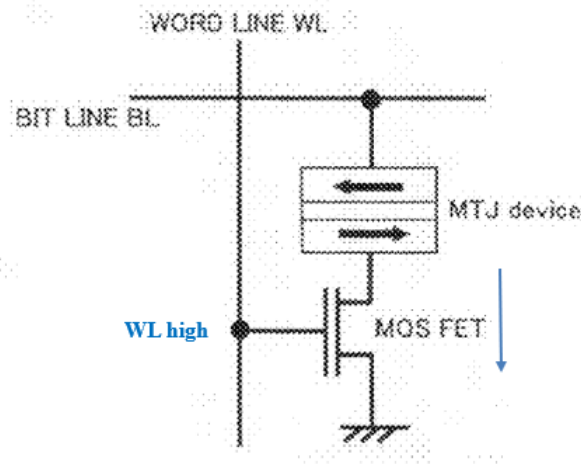
The MTJ device’s resistance to current flow through the device depends on the electrode magnetization, making the MTJ device a magnetoresistive device. EX1005, 1:44-59. The resistance R_{ap} in the antiparallel state is **higher** than the resistance R_p in the parallel state. *Id.* By applying appropriate 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. EX1005, 1:23-2:19. 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. EX1005, 1:44-59 (“information ‘1’ or ‘0’ can be stored depending on whether the [MTJ] resistance value is high or not”), 2:2-4 (“[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”). EX1005, Figs. 9(B) (annotated below), 9(C); 2:2-5.

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. EX1005, 1:28-34, 1:44-46, 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.

EX1005, 1:66-2:6. 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.*, 1:38-59; 1:66-2:6.

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. EX1005, 2:25-50. 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.*, 4:51-60; 8:13-20. This reduces read-out errors by making it easier to distinguish between the voltages reflecting stored “1s” and stored “0s.” *Id.*, 2:42-46.

A parameter the ’134 Patent calls the “magnetoresistance ratio” (“MR ratio”) quantifies the difference between the MTJ device’s magnetoresistance in its antiparallel and parallel states. *Id.*, 4:53-60. The ’134 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 ’134 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, 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., 6.

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

III. THE ’134 PATENT

A. Disclosed Embodiments

Dr. Shinji Yuasa, the ’134 Patent inventor, discovered how to make an MTJ device with an increased TMR. EX1005, 7:55-60 (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. EX1005, 5:15-23. 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.*, 5:21-23. 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.*, 5:18-61.

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.

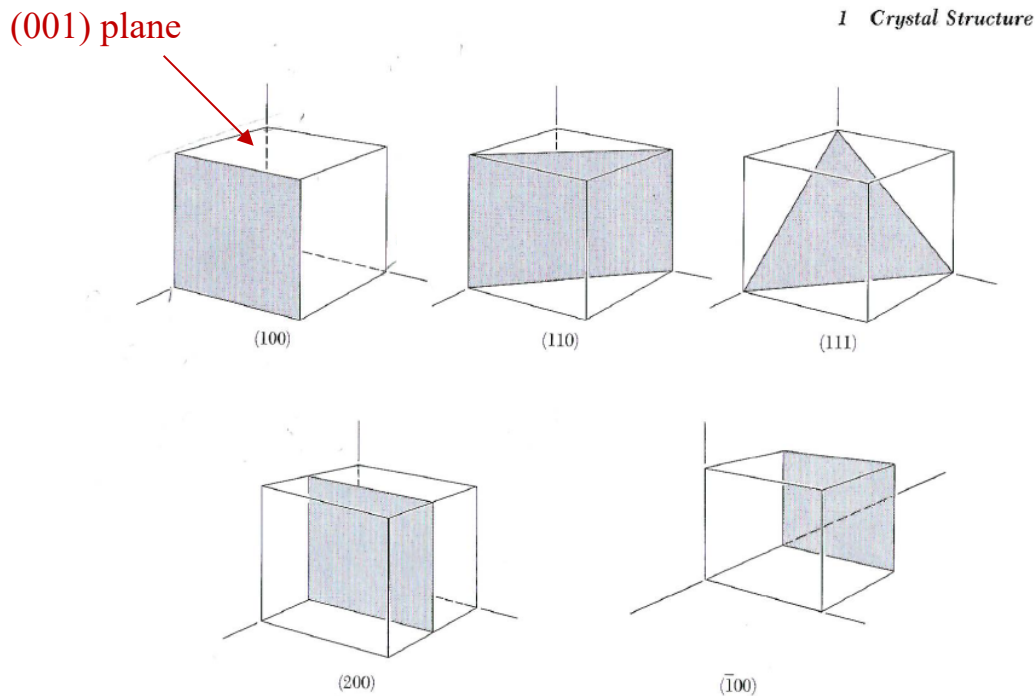
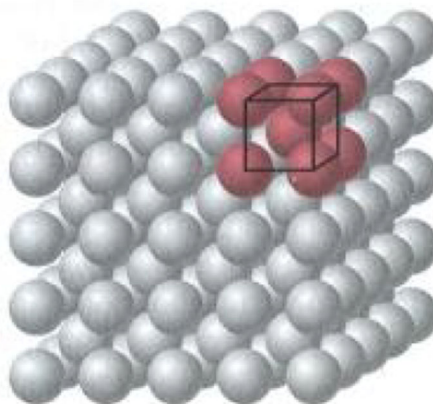
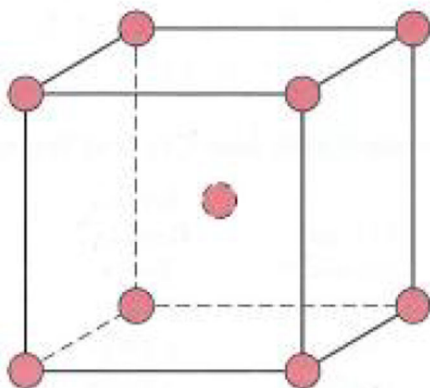


Figure 16 Indices of important planes in a cubic crystal. The plane (200) is parallel to (100) and to $(\bar{1}00)$.

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 crystalline structure sandwiching a single-crystalline MgO(001) layer. EX1005, 8:56-9:10; 5:27-6:22.

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.” EX1005, 3:7-11, Figs. 9(B), 9(C), 10 (“characteristics required for G bit-MRAM”).

B. Challenged Claims

The Petition challenges Claims 1-4 (“Challenged Claims”). Claims 1 and 3 are independent and Claims 2 and 4 depend therefrom. Claims 1 and 3 recite, *inter alia*, a tunnel barrier layer disposed between first and second ferromagnetic layers,

and “at least said first ferromagnetic material layer is crystallized [or “entirely crystallized”] and comprises CoFeB alloy.” Limitations 1[c], 1[e], 3[c], and 3[e].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, 27-28) 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 Claim 1 “would have been obvious over Bowen in view of Sunai or Parkin.” Petition, 28. 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 v. Teleflex*, 550 U.S. 398, 418 (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).

³ Patent Owner adopts Petitioner’s claim limitation labelling. Petition, xiv-xv (“List of Challenged Claims”).

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 ’134 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. Limitation 1[e] Requires that the First Ferromagnetic Layer Is Crystalline

Limitation 1[e] requires that “said first ferromagnetic material layer is crystallized and comprises CoFeB alloy.” The reference to “crystallized” means that the first ferromagnetic material layer 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, 37 (“Annealing...to crystallize”), 38 (“anneal ... to obtain a crystalline ferromagnetic layer”).

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 further that it would have been

obvious “to crystallize Sunai’s CoFeB” layer. Petition, 35-37. This argument fails because Sunai *teaches away* from a ferromagnetic layer with the crystalline structure recited in Limitation 1[e]. “[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, 35-36 (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 a CoFeB alloy*”).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* 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

⁴ 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.

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, 6. 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, 35.

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, 35-36) by using a ferromagnetic layer with Sunai’s CoFeB and “to crystallize” the CoFeB. Petition, 37. 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, 35) then the POSA would have been motivated to *avoid* a crystalline structure for the CoFeB layer.

The Petition points to other evidence to support its alleged motivation to use a crystalline CoFeB layer in Bowen, but that evidence similarly fails. Petition, 35-36. Petitioner cites EX1035 for the proposition that “CoFe was known to obtain better results than Fe[.]” Petition, 35. But as noted above, EX1035 never describes boron or a CoFeB ferromagnetic layer. *Supra* footnote 5. EX1056 describes “an amorphous structure” of CoFeB or CoFeNiB. EX1056, [0036]; EX1056, Abstract, [0039]. The Petition also states “[o]ther researchers obtained similar results” and cites to EX1055 and EX1056. Petition, 36. However, as discussed above, these references are about amorphous, not crystalline CoFeB. 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*”).

Contrary to Petitioner’s assertion that EX1060 showed structures with crystalline CoFeB and improved TMR and other characteristics (Petition, 37-38), in fact, EX1060 does not disclose crystalline CoFeB. *See* EX1060, Title (“...*amorphous* CoFeB”), §V.A.2.c.ii(1) (discussing *absence* of crystallized CoFeB in EX1060). Thus, EX1060 would not motivate adoption of crystallized CoFeB. Similarly, EX1061 teaches it would be “unexpected” for CoFeB to be crystallized because “other groups obtained amorphous films when ... Boron was incorporated.” EX1061, 2273. In any event, a POSA would understand that the results from EX1061 are not applicable in Petitioner’s proposed combination, as explained *infra* §V.A.2.c.ii(2), and thus would not motivate the proposed modification. EX1045 is also irrelevant because, as Petitioner admits, it relates to crystallization of MgO and Fe structures, not CoFeB. Petition, 38 (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. *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” (Petition, 39) by using a “crystalline ferromagnetic layer” (Petition, 38).

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 “to increase TMR.” Petition, 40. 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.

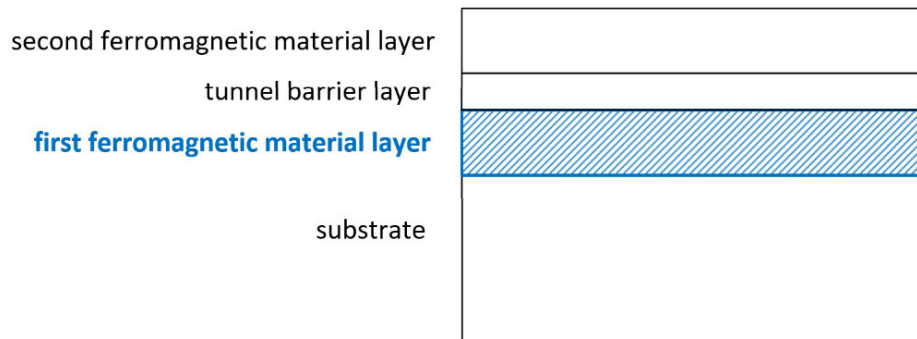
Second, like Sunai, Parkin teaches that “high TMR [was] observed in [Parkin's] devices and structures,” even though those structures “contain significant atomic disorder” or, in other words, are substantially amorphous. EX1062, 15:42-61, *see also* EX1062, 18:49-51 (“very high TMR values are unexpectedly 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[e]. Petition, 36-40. 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 infra* §§V.A.2.b-d.

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

Claim 1 recites “at least said first ferromagnetic material layer is crystallized and comprises CoFeB alloy.” Limitation 1[e].



Limitations 1[a]-1[b] recite a “first ferromagnetic material layer” and “a second ferromagnetic material layer.” The “first ferromagnetic material layer [is] deposited on a substrate” and a tunnel barrier layer is “located between the first and second ferromagnetic material layers.” *See* Limitation 1[a]-1[c]. An exemplary configuration is depicted in the illustration above.

Limitation 1[e] requires that “at least said first ferromagnetic material layer is crystallized and comprises CoFeB alloy.”

For the reasons detailed below, the Petition fails to establish that its Bowen-Sunai or Bowen-Parkin combination has such a claimed ferromagnetic layer with a crystalline CoFeB structure as alleged to meet Limitation 1[e].

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

The Petition alleges that “[c]laim 1[e] does not specify any molecular composition or stoichiometry of the claimed CoFeB alloy, and thus *any CoFeB alloy satisfies it.*” Petition, 34.

The Petition then alleges that Petitioner’s Bowen-Sunai combination meets Limitation 1[e] because “Bowen disclosed or suggested a first Fe ferromagnetic material layer” and a POSA would have “substitute[d] Sunai’s CoFeB electrode for Bowen’s first electrode” (Petition, 34-36) and then “crystallize Sunai’s CoFeB electrode” by “[a]nnealing” “to obtain a crystalline ferromagnetic layer.” (Petition, 37-38). “Alternatively,” the Petition argues that a POSA would “replace Bowen’s first ferromagnetic material layer (Fe layer) with Parkin’s ... CoFeB layer,” which Petitioner alleges to be “crystallized” (Petition 39-40). But as explained below, Petitioner’s evidence fails to support the Petition’s assertions. 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 material layer (Fe layer) with a CoFeB ferromagnetic layer as taught by Sunai to increase TMR.” Petition, 35; *see also id.*, 36 (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 “crystallized ... CoFeB alloy” as Petitioner alleges to meet Limitation 1[e]. Petition, 34; *see also id.*, 34 (Limitation 1[e] is met by “any 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.⁵ EX1030, [0024]. Sunai teaches that boron inhibits and 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]]

⁵ 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 is like H₂O nomenclature means that for every oxygen (O) atom there are 2 hydrogen (H) atoms.

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 relatively freely, making crystallization more likely to occur.”).

Because Sunai’s CoFeB ferromagnetic layer is not crystalline, it is not a “crystallized ... CoFeB alloy.” *See* Petition, 34; *supra* §§III.A, V.A.1.a(i). 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, 35), that would not have yielded “crystallized” CoFeB structure as Petitioner alleges to meet Limitation 1[e] because Sunai’s CoFeB layer is not a crystalline structure, let alone a “crystallized ...CoFeB alloy.” Petition, 34-35.

c. Petitioner’s Assertion that Annealing Sunai’s CoFeB Layer Would Have Produced a Crystallized CoFeB Structure Fails

Petitioner does not allege that Sunai teaches that its CoFeB layer is a crystalline CoFeB structure as alleged to meet Limitation 1[e]. Petition, 34-37. In fact, Petitioner concedes that Sunai’s CoFeB layer is amorphous. Petition, 37. “It was known that adding boron (B) resulted in an amorphous CoFeB layer with ‘inhibited’ crystallization.” Petitioner, 37. Petitioner’s reference to “‘inhibited’ crystallization” misleadingly suggests there is crystallization, when there is none.

See EX1030, [0025]. What Sunai states is “crystallization *is inhibited*”, meaning there is no crystallization. EX1030, [0025], *see also* EX1030, [0029]-[0030] (addition of boron “suppress[es] crystallization” whereas absent boron, “crystallization [is] more likely to occur”).

Petitioner further alleges that if Sunai’s non-crystalline CoFeB layer had been used in Bowen’s device, it would have then been converted into a crystalline structure by annealing (Petition, 37-38). Petitioner alleges that “[a]nnealing CoFeB electrodes to crystallize them also was known” and that a POSA would have “anneal[ed] Bowen’s MTJ with CoFeB to obtain a crystalline ferromagnetic layer.” Petition, 37-38. Petitioner’s assertions are unfounded.

i. Annealing Considerations

Annealing is a process involving heating a material, the result of which depends at least on the material, the annealing conditions (*e.g.*, temperature, duration), and surrounding structures including the materials and crystal properties of the surrounding structures. EX2009, G1 (defining “[a]nnealing” as “denot[ing] a heat treatment wherein the microstructure and, consequently, the properties of a material are altered”); EX2015, 87 (defining “anneal” as “to heat and then cool (as steel or glass) usu[ally] for softening and making less brittle”), *see also* EX2016, 16 (structure and properties of nanostructured material “depend not only on the chemical composition and the size/shape of the crystallites but also on the mode of

preparation and the previous time-temperature history of the material”). The condition-dependent result of annealing is seen from the references to which Petitioner cites.

For example, Parkin teaches that annealing a CoFeB layer positioned above a crystallized MgO layer results in the formation of a thin crystalline layer, with the remainder of the layer being amorphous. EX1062, 18:55-62. The crystal structure of the MgO layer on which the CoFeB layer is deposited “provides a template” for the formation of the thin crystal layer. EX1062, 18:55-59. Still, even with the template of the crystal MgO layer, “the bulk” of the CoFeB layer is amorphous. EX1062, 18:59-62. Thus, to the extent Parkin discloses that the result of annealing an amorphous CoFeB layer results in some crystallization, Parkin teaches that the result depends on the annealing conditions including the underlying layer material and crystal properties. EX1062, 8:61-64, 23:49-52, Figs. 4A-4B, 6.

Likewise, EX1061 states that CoFeB layers with a (111) texture (meaning crystal orientation) are formed by following the conditions specified in that reference, including using the neighboring materials shown in FIG. 1B. EX1061, 2272-73. The (111) texture is a different crystal orientation than that of the MgO layer in Bowen.

Thus, Petitioner's overly broad statement that "[a]nnealing CoFeB electrodes to crystallize them also was known" (Petition, 37) fails to account for the conditions required to achieve a crystal CoFeB layer by annealing.

ii. The Petition Does Not Establish With Evidence That Bowen Provides the Conditions That Would Allow For Annealing to Produce a Crystallized CoFeB Layer

The Petition fails to establish that the conditions required to achieve a crystal CoFeB layer in the proposed combination of Bowen and Sunai exist.

Ground 1 proposes that a POSA would have replaced Bowen's Fe electrodes with CoFeB electrodes, and annealed the resulting CoFeB electrodes, but never sets forth the conditions of the proposed annealing, including the timing during device fabrication at which the anneal would allegedly have been performed. Petition, 37-39.

Petitioner relies on EX1060 and EX1061 (Petition, 37), which describe two different annealing procedures, neither of which is applied to a device having the surrounding structures and material properties present in Bowen. *See* EX1060, 308; EX1061, 2272-73. Neither discloses that its annealing process would be adequate to achieve a crystallized CoFeB layer in the context of Bowen's device. *Id.*

Petitioner's expert merely quotes EX1060 and EX1061, again failing to disclose what annealing protocol Petitioner contemplates. *See* EX1024, ¶139-142.

By failing to identify a specific prior art annealing process yielding the claimed “crystallized” CoFeB alloy, Petitioner fails to meet its burden under 37 C.F.R § 42.104(4) to “specify where each element is found.”

To the extent Petitioner’s theory is that *any* form of annealing will inherently yield crystallized CoFeB, that theory is defeated by EX1060 and EX1061, which fail to show crystallized CoFeB. *See below* Section V.A.2.c.ii(1)-(2). At a minimum, Petitioner fails to meet its burden to show a reasonable expectation of success in obtaining crystallized CoFeB by referring only to unspecified “[a]nnealing.” *Arctic Cat Inc. v. Bombardier Recreational Prods. Inc.*, 876 F.3d 1350, 1360-61 (Fed. Cir. 2017) (“where a party argues a skilled artisan would have been motivated to combine references, it must show the artisan ‘would have had a reasonable expectation of success from doing so’”); *NJOY, LLC v. JUUL LABS, Inc.*, IPR2024-00536, Paper 17, 36 (PTAB Aug. 12, 2024) (“The burden of proving a reasonable expectation of success [is] on Petitioner.”).

None of the evidence Petitioner cites supports Petitioner’s assertion that crystallized CoFeB would result from annealing the CoFeB layer allegedly resulting from the Bowen-Sunai combination. The Petition cites EX1060 (“Jimbo”) at 309, 311 and EX1061 (“Cordoso”) at 2272-73 as allegedly supporting the assertion that “[a]nnealing CoFeB electrodes to crystallize them ... was

known” (Petition, 37-38). But as explained below, none of Petitioner’s citations support its argument.

(1) EX1060 Does Not Support Petitioner’s argument

Petitioner’s reliance on EX1060 at 311 as allegedly disclosing that “[a]nnealing CoFeB electrodes to crystallize them ... was known” (cited at Petition, 37-38) 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”).

Contrary to Petitioner’s assertion that EX1060 shows crystalline CoFeB after annealing (Petition, 37-38), 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”); *see also, supra*, §V.A.1.a.ii. Additionally, EX1060 does not even discuss MgO layers, let alone crystalline MgO layers.

EX1060 provides no support for Petitioner’s assertion that “anneal[ing] Bowen’s MTJ with CoFeB” would “obtain a crystalline [CoFeB] ferromagnetic layer.” Petition, 38.

(2) EX1061 Does Not Support Petitioner’s Argument

Petitioner cites EX1061 as describing “CoFeB films [that] are not amorphous.” Petitioner, 37-38 (citing EX1061 at 2272-73). However, EX1061 does not support Petitioner’s argument.

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.

d. Petitioner Fails to Establish That the Proposed Modification of Bowen Based on Parkin Would Have Resulted in a Ferromagnetic Layer with a Crystalline CoFeB Structure Meeting Claim 1

Petitioner's allegation that a POSA would have modified Bowen based on Parkin in a manner meeting Limitation 1[e] is unsupported. Petition, 39. As an initial matter, Petitioner misapplies the law, arguing that Limitation 1[e] "is also obvious." Petitioner, 39. The proper test for obviousness is whether a claim as a whole would have been obvious, and not whether an individual limitation would have been obvious. *W.L. Gore & Assocs., Inc. v. Garlock, Inc.*, 721 F.2d 1540,

1548 (Fed. Cir. 1983); *Sanofi-Synthelabo v. Apotex, Inc.*, 550 F.3d 1075, 1086 (Fed. Cir. 2008). Petitioner’s error in this regard is not a mere technicality, but instead underscores Petitioner’s flawed approach to combining Parkin with Bowen.

i. Parkin’s CoFeB Layer Has Crystallized CoFe, and Amorphous CoFeB, Not Crystallized CoFeB

Petitioner alleges that a POSA would “replace Bowen’s first ferromagnetic material layer (Fe layer) with Parkin’s ... CoFeB layer,” which Petitioner alleges to be “crystallized.” Petition 39-40. Even if Petitioner were correct that a POSA would have been motivated to replace Bowen’s first ferromagnetic layer with Parkin’s CoFeB ferromagnetic layer (which Patent Owner does not concede), Petitioner fails to establish that the resulting combination would have had a “crystallized ... CoFeB alloy” as Petitioner alleges to meet Limitation 1[e]. Petition, 39-40; *see also id.*, 34 (Limitation 1[e] is met by “any CoFeB alloy”).

Like Sunai’s CoFeB ferromagnetic layer, the CoFeB in Parkin’s layer 175 is *non-crystalline*. More specifically, Parkin states that its “layer 175 adjacent to the MgO tunnel barrier 120’ has crystallized [is] *a thin crystalline ferromagnetic layer which has the bcc structure of CoFe* [*not CoFeB*, and that] the bulk of the storage layer 175 remains amorphous.” EX1062, 18:49-60. This is consistent with Sunai, which teaches that its CoFeB layer was amorphous (not crystalline) because boron inhibited and suppressed crystallization (EX1030, [0024]-[0025], [0030]).

These teachings directly refute Petitioner's assertion that Parkin would have motivated a POSA to modify Bowen to "increase TMR" (Petition, 35-36) by using a ferromagnetic layer with crystallized CoFeB from Parkin.

ii. The Claimed First Ferromagnetic Material Layer Has a Specific Position

Limitation 1[e] refers to a "first ferromagnetic material layer." Claim 1 specifies the location of that first ferromagnetic material layer. Limitation 1[a] specifies that the first ferromagnetic material layer is deposited on a substrate. Limitation 1[c] specifies that the claimed tunnel barrier layer is located between the first and second ferromagnetic material layers, and Limitation 1[d] specifies the characteristics of that tunnel barrier layer.

iii. Parkin's CoFeB Layer Is Not Positioned As Required by Claim 1

Petitioner alleges that a POSA would have replaced Bowen's electrodes with CoFeB based on Parkin's layer 175, shown below in an annotated version of Parkin's FIG. 3A taken from the Petition. Petition, 39.

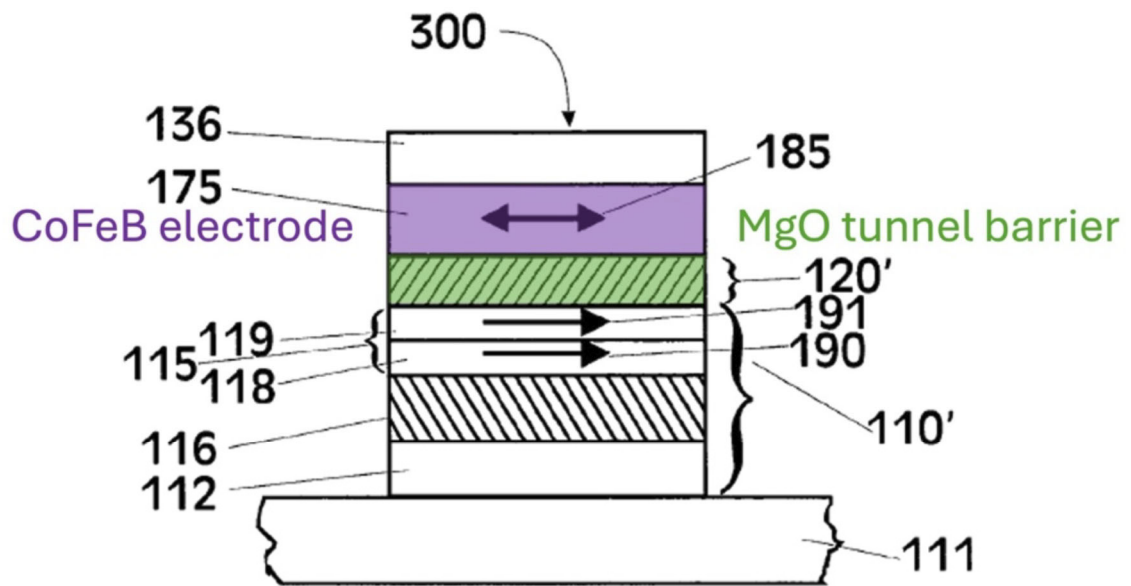


FIG. 3A

Layer 175 is not positioned as required by Claim 1 of the claimed first ferromagnetic material layer. Layer 175 is above the MgO tunnel barrier layer 120' such that the MgO tunnel barrier 120' is not located between first and second ferromagnetic material layers. EX1062, 17:4, 17:21-44. Parkin's FIG. 3A includes additional ferromagnetic layers 118 and 119, but notably neither one is made of CoFeB. EX1062, 13:11-13.

Parkin's layer 175 is intentionally positioned above the MgO tunnel barrier layer 120'. EX1062, 17:4, 17:21-44. Parkin teaches that the MgO tunnel barrier layer 120' has a crystal structure serving as a template for the subsequent formation of the layer 175. EX1062, 17:40-46, 18:49-19:27. Even with that template represented by the crystalline MgO tunnel barrier layer 120', the layer

175 is substantially amorphous. EX1062, 18:59-60. Parkin does not disclose that the MgO tunnel barrier layer 120', which is intended to be crystalline, can be formed on an amorphous CoFeB layer such as layer 175. EX1062, 17:21-39.

Thus, simply including Parkin's CoFeB layer 175 in Bowen's device would not have met the requirements of the claimed first ferromagnetic material layer. Instead, Petitioner's proposed modification of Bowen to include Parkin's CoFeB layer represents the placement of the CoFeB layer at a position within the device which Parkin never intended, as explained further below. *See infra* §V.A.2.d.iv.

iv. The Petition Mischaracterizes Parkin by Asserting that Parkin Discloses a CoFeB Layer Positioned as Required by Claim 1

Petitioner effectively acknowledges that Parkin's CoFeB layer 175 is not positioned as required by Claim 1, and therefore that simply replacing Bowen's electrode with Parkin's layer 175 would not have met the requirements of Claim 1. Petition, 40. This is why the Petition states that "Parkin itself teaches that the top and bottom electrodes in Figure 3A may be 'inverted.'" Petition, 40. Such inversion of the electrodes would be irrelevant if Parkin's layer 175 were positioned as required by Claim 1.

Yet, the Petitioner mischaracterizes Parkin's teachings. What Parkin says is that "The MTJ device of FIG. 3A may also be inverted, such that the reference ferromagnetic electrode [115] is formed above the tunnel barrier and the storage

layer [175] is formed beneath the tunnel barrier.” EX1062, 17:7-10. The references to the “reference ferromagnetic electrode” and the “storage layer” refer to the functions of those layers, not the material. It is neither explicit nor inherent in Parkin that the ferromagnetic layer formed below the tunnel barrier is formed of crystalline CoFeB. Parkin itself makes this point.

“FIG. 11 shows another representative embodiment of the current invention in which the structure of the devices shown in FIGS. 3A and 3B is inverted so that the storage layer or electrode is formed beneath the tunnel barrier and the reference electrode is formed above the tunnel barrier.” EX1062, 22:29-33. In this configuration, the device includes a storage magnetic electrode 510, MgO tunnel barrier 540 and reference magnetic electrode 560. EX1062, 22:56-58; 23:6-15. The storage magnetic electrode 510 “is formed on the underlayer 512 by deposition of a *layer 515 comprising an amorphous ferromagnetic alloy.*” EX1062, 22:56-58. That is, although the storage layer and reference electrode are inverted compared to the device of FIG. 3A, the electrode beneath the tunnel barrier (540) is amorphous, not crystalline.

v. A POSA Would Not Have Positioned a Crystalline CoFeB Layer As Required by Claim 1 Based on Parkin

Based on the foregoing, and contrary to the assertion in the Petition, a POSA would not have replaced Bowen's electrode with a crystalline CoFeB layer based on Parkin in a manner meeting the requirements of the claimed first ferromagnetic material layer. As explained *supra* §V.A.2.d.iii, Parkin's placement of layer 175 is intentionally above the MgO tunnel barrier layer 120' in Parkin's FIG. 3A.

EX1062, 17:4, 17:21-44. Again, this is because the MgO tunnel barrier layer 120' serves as a template for layer 175. EX1062, 17:40-46, 18:49-19:27. Parkin does not contemplate or teach how the amorphous layer 175 could be used underneath the crystalline MgO tunnel barrier layer 120', and for that reason explicitly teaches the use of other materials – not CoFeB – beneath the MgO tunnel barrier layer 120'. Accordingly, a POSA would not have modified Bowen based on Parkin to include a CoFeB layer beneath Bowen's tunnel barrier layer in any manner that would have met the requirements of Claim 1 based on Parkin, but in fact would have avoided such a modification.

e. Conclusion: Petitioner Fails to Establish that Its Bowen-Sunai or Bowen-Parkin Combination Would Have a "Crystallized" CoFeB Structure as Alleged to Meet Limitation 1[e]

The Petition alleges that "any CoFeB alloy satisfies" Limitation 1[e] (Petition, 34) and that Petitioner's Bowen-Sunai or Bowen-Parkin combination

meets Limitation 1[e] because that combination purportedly has “an interface of crystalline CoFeB” (Petition, 40). But as explained above, Petitioner’s evidence fails to support Petitioner’s assertion that its Bowen-Sunai or Bowen-Parkin combination has “crystallized” CoFeB meeting claim 1. *Id.* Ground 1 fails for this 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. The Petition focuses on importing from Sunai or Parkin a CoFeB ferromagnetic layer as is or alternatively crystallizing that CoFeB ferromagnetic layer through an annealing process (which as discussed above is not explained in any detail). Petition, 36-40. The Petition otherwise relies on Bowen to meet the claimed limitations requiring a “tunnel barrier layer located between the first and second ferromagnetic layers” and “wherein said tunnel barrier layer comprises a single-crystalline magnesium oxide . . . or a poly-crystalline magnesium oxide.” Petition, 31-33.

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, 31-33. 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 “single-crystalline magnesium oxide [or] poly-crystalline magnesium oxide” tunnel barrier layer as Bowen is alleged to disclose could be grown on the substituted CoFeB layer of Sunai or Parkin. Petition, 31-34. 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, 39), Parkin's layer 175 is amorphous in bulk with the possible exception of the interface with 120'. EX1062, 18:59-62.

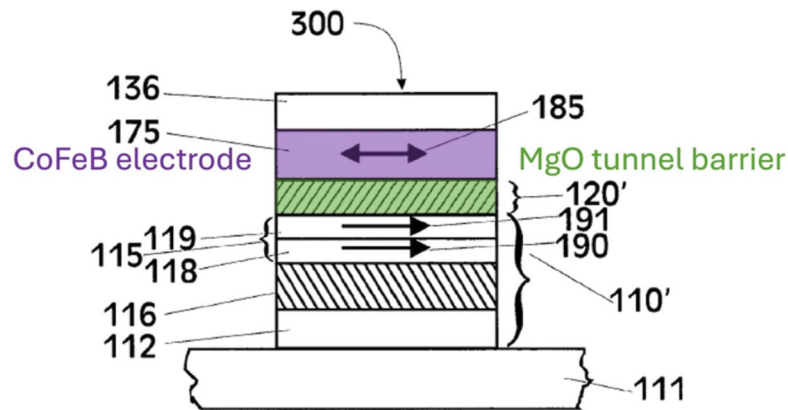


FIG. 3A

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 “single-crystalline magnesium oxide [or] poly-crystalline magnesium oxide” 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 1’s Challenges to Claims 2-4 Fail For the Same Reasons.

Independent Claim 3 requires a “first ferromagnetic material layer” that is “entirely crystallized...CoFeB alloy” (Limitation 3[e]). With respect to Claim 3, 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. Petition, 45-48. Accordingly, for the same reasons explained above with respect to Claim 1, Ground 1 fails with respect to independent Claim 3. *See supra* §§V.A.1-V.A.3.

For dependent Claims 2 and 4, 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.3.

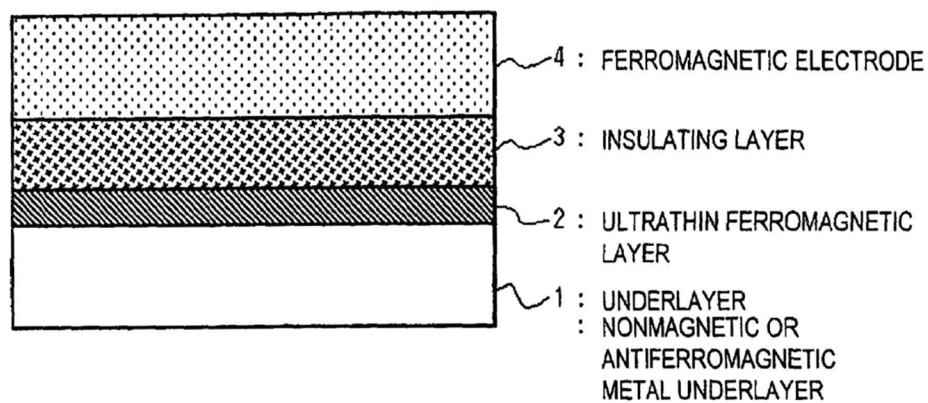
B. Ground 2 (Nagahama-Sunai or Nagahama-Parkin) Fails

In Ground 2, Petitioner contends that Claim 1 “would have been obvious over Nagahama in view of Sunai or Parkin.” Petition, 50. 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[e].

FIG. 3



EX1027, Fig. 3 (cited at Petition, 52)

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 “[Claim 1[e]] does not specify any molecular composition or stoichiometry of CoFeB, and thus *any CoFeB alloy satisfies it.*” Petition, 56. The Petition then alleges that Petitioner’s Nagahama-Sunai or Nagahama-Parkin combination meets Limitation 1[e] because that combination purportedly would have “replace[d] Nagahama’s lower ferromagnetic electrode

material with CoFeB as taught by Sunai” (Petition, 57) and “anneal” it (Petition, 59), or “[a]lternatively” with “Parkin’s [allegedly] crystallized CoFeB layer” (Petition, 60). But as explained below, Petitioner’s evidence fails to support Petitioner’s assertion that its Nagahama-Sunai or Nagahama-Parkin combination has a crystallized 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 relies upon its arguments from Ground 1 to allege that “annealing CoFeB electrodes to crystallize them was known.” Petition, 59.

Similarly, as explained above (*supra* §V.A.2.d.i), Parkin states that its “layer 175 adjacent to the MgO tunnel barrier 120’ has crystallized [is] *a thin crystalline ferromagnetic layer which has the bcc structure of CoFe* [*not* CoFeB], and that] the bulk of the storage layer 175 remains amorphous.” EX1062, 18:49-60.

Petitioner asserts that its combination yields a *crystallized* CoFeB layer rendering Claim 1 obvious as a “combination of familiar elements.” Petition, 58-60. That is simply untrue. Petitioner presents no evidence that substituting Sunai’s or Parkin’s CoFeB layer into Nagahama’s structure would yield a crystallized 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 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. 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, 59) 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.a.ii), 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. Thus, Petitioner’s theory that a POSA would have been motivated to combine Parkin with Nagahama to “improv[e] the 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 “material” in Nagahama to increase

TMR by forming a *crystallized* CoFeB structure. Petition, 59-60. A POSA would have done no such thing. Ground 2 fails for that reason alone.

3. Petitioner’s Assertions Regarding Annealing CoFeB Fail To Support Petitioner’s Position That Claim 1 Would Have Been Obvious

Petitioner relies on the same conclusory assertions from Ground 1 relating to the allegation that a POSA would have annealed CoFeB in Bowen’s device.

Petition, 59-60. Ground 2 fails for the same reasons. *Supra* §V.A.2.c.

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

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 or Nagahama-Parkin combination to have a CoFeB layer with a crystallized structure as alleged to meet Limitation 1[e]. Petition, 60-61.

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 or Parkin’s CoFeB alloy to form the ferromagnetic electrodes of Nagahama’s MTJ device. Petition, 61. 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]. And Parkin’s layer 175, has “***a thin crystalline ferromagnetic layer which has the bcc structure of CoFe [not CoFeB, and] the bulk of the storage layer 175 remains amorphous.***” EX1062, 18:49-60. In addition, Parkin’s layer 175 which Petitioner relies on in the Nagahama-Parkin combination (*see* Petition, 60 (citing EX1062, 19:15-22)), is not positioned as required by Claim 1 of the claimed first ferromagnetic material layer. *See* EX1062, 17:4, 17:21-44; *supra* §V.A.2.d

While Petitioner alleges that a POSA had a reason to want to make Sunai’s or Parkin’s CoFeB layer in a crystallized 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 *crystallized* CoFeB layer despite Sunai’s teaching that boron inhibits and suppresses crystallinity. Petition, 61; 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 *crystalline* CoFeB layer as claimed. 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.

Thus, the Petition fails to carry its burden to establish that a POSA would have reasonably expected success in forming such a structure. Petition, 60-61. Ground 2 fails for this additional reason.

5. 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 (which, as discussed above, is not explained in any detail). Petition, 58-61. The Petition otherwise relies on Nagahama to meet the claimed limitations requiring a “tunnel barrier layer located between the first and second ferromagnetic layers” and “wherein said tunnel barrier layer comprises a single-crystalline magnesium oxide . . . or a polycrystalline magnesium oxide.” Petition, 53-56.

The Petition never addresses the impact of replacing Nagahama’s “(001)-highly-oriented lower ferromagnetic layer” (Petition, 50 (citing EX1027, [0073]-[0074])) 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, 53-56. 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 “single-crystalline magnesium oxide [or] polycrystalline magnesium oxide” tunnel barrier layer as Nagahama is alleged to disclose could be grown on the substituted CoFeB layer of Sunai or Parkin. *Id.* 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 “single-crystalline magnesium oxide [or] poly-crystalline magnesium oxide” 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.

6. Ground 2’s Challenges to Claims 2-4 Fail For the Same Reasons.

Independent Claim 3 requires a “first ferromagnetic material layer” that is “entirely crystallized...CoFeB alloy” (Limitation 3[e]). With respect to Claim 3, the Petition refers back to the arguments for Claim 1 and/or repeats the same arguments for replacing Nagahama’s ferromagnetic layer with a crystallized CoFeB alloy. Petition, 64. Accordingly, for the same reasons explained above with respect to Claim 1, Ground 2 fails with respect to independent Claim 3. *See supra* §§V.B.2-V.B.5.

For dependent Claims 2 and 4, 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.B.2-V.B.5.

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 I

Date: January 23, 2025

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VII. APPENDIX: U.S. PATENT NO. 8,405,134 CLAIM LIST

Ref	Limitation
1[preamble]	A magnetoresistive device having a tunnel barrier junction structure, the magnetoresistive device comprising:
1[a]	a first ferromagnetic material layer deposited on a substrate;
1[b]	a second ferromagnetic material layer; and
1[c]	a tunnel barrier layer located between the first and second ferromagnetic material layers, and
1[d]	wherein said tunnel barrier layer comprises a single-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented or a poly-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented, and
1[e]	at least said first ferromagnetic material layer is crystallized and comprises CoFeB alloy.
2	The magnetoresistive device according to claim 1, wherein said second ferromagnetic material layer is also crystallized and comprises CoFeB alloy.
3[preamble]	A magnetoresistive device having a tunnel barrier junction structure, the magnetoresistive device comprising:
3[a]	a first ferromagnetic material layer deposited on a substrate;
3[b]	a second ferromagnetic material layer; and
3[c]	a tunnel barrier layer located between the first and second ferromagnetic material layers, and
3[d]	wherein said tunnel barrier layer comprises a single-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented or a poly-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented, and
3[e]	wherein at least said first ferromagnetic material layer is entirely crystallized and comprises CoFeB alloy.
4	The magnetoresistive device according to claim 3, wherein said second ferromagnetic material layer is also entirely crystallized and comprises CoFeB alloy.

CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24, the undersigned certifies that the foregoing **PATENT OWNER'S PRELIMINARY RESPONSE** contains 12,283 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: January 23, 2025

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

I certify that on January 23, 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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