Attorney Dkt. No.: 1556-1003

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of	: Shinji Yuasa	Examiner: Not Yet Assigned Group Art Unit: Not Yet Assigned Customer No.: 188787
Patent No.	11,968,909	
Issue Date	4/23/2024	
Application No.	18/219,320	
Filing Date	7/7/2023	
Title	METHOD OF MANUFACTURING A MAGNETORESISTIVE RANDOM ACCESS MEMORY (MRAM)	

REQUEST FOR *EX PARTE* REEXAMINATION OF U.S. PATENT NO. 11,968,909

Mail Stop *Ex Parte* Reexam
Central Reexamination Unit
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

Pursuant to 35 U.S.C. § 302 and 37 C.F.R. § 1.510 *et seq.*, the undersigned requests *ex parte* patent reexamination of Claims 5–6 and 9–20 of U.S. Patent No. 11,968,909 currently assigned to Patent Owner Godo Kaisha IP Bridge 1 on behalf of Requester Western Digital Technologies, Inc. The fee set forth in 37 C.F.R. § 1.20(c)(1) is submitted herewith.

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TABLE OF EXHIBITS

Exhibit No.	Description
1	U.S. Patent No. 11,968,909 ("'909 Patent")
2	File History for U.S. Patent No. 11,968,909
3	Statutory Disclaimer of U.S. Patent 11,968,909, filed February 10, 2025
4	Japanese Patent Application No. 2000-106462 to Kishi et al. ("Kishi") (certified translation)
5	U.S. Patent Application Publication No. 2009/0324814 to Parkin ("Parkin")
6	File History for U.S. Patent Application No. 18/232,576 ("'576 Application")
7	File History of U.S. Patent Application No. 10/646,246 ("'246 Application")
8	File History for U.S. Patent No. 7,884,403
9	G. Pacchioni, et al., *Ab initio theory of point defects in oxide materials: structure, properties, chemical reactivity*, Solid State Sciences 2:161-79 (2000)
10	*Western Digital Technologies, Inc. v. Godo Kaisha IP Bridge 1*, Decision Granting Institution of *Inter Partes* Review, Paper 9 (P.T.A.B. Apr. 30, 2025)
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** Consecutive page numbering has been added to large documents*

I. INTRODUCTION

The Office materially erred in allowing the claims of U.S. Patent No. 11,968,909. During examination of the '576 child application to the '909 Patent, Patent Owner conceded that a claim identical in scope to Claim 9 of the '909 Patent is unpatentable based on the Kishi prior art not previously cited or considered during prosecution of the '909 Patent. This Request accordingly challenges the claims of the '909 Patent based on the same prior art.

Patent Owner can no longer defend patentability of the claims of the '909 Patent. It already statutorily disclaimed six claims of the '909 Patent after Requestor filed an IPR Petition challenging them. Statutory Disclaimer of '909 Patent (Ex. 3). And now the Examiner's original basis for allowing the rest of the claims has collapsed. '909 Patent File History (Ex. 2) at 170.

During original examination of the '909 Patent, applicant distinguished the claimed invention over the prior art solely on the basis of the recited "barrier height" limitations requiring either a claimed barrier height of "0.1 eV to 0.85 eV" or "0.2 eV to 0.5 eV." '909 Patent (Ex. 1) at 10:14-19 (Claims 5–6). Again, during the pending IPR, Patent Owner argued that the claims are patentable because the prior art fails to disclose an MgO MTJ with "a tunnel barrier height within either claimed range." *E.g.*, Patent Owner Response (Ex. 11) at 58.

There has never been any dispute that the prior art disclosed a barrier height of 0.9 eV, which is just outside the broader claimed range. Ex. 1 at 7:26-28 (noting "experimental values of 0.9" eV for an MgO tunnel barrier); Ex. 2 at 151. Recent events show that these claims should never have issued in the first place. After Applicant filed a child '576 Application containing nearly identical claims to the '909 parent patent, Patent Family Tree (Ex. 13), the same Examiner withdrew them from allowance and rejected the claims "as being clearly anticipated by Kishi et al. (JP2000-106462)" because "Kishi teaches a barrier height of (0.1 eV to 0.85 eV) and (.2eV to

.5eV)." '576 Application File History (Ex. 6) at 257; *see also id.* at 254–61 (June 26, 2024 Office Action). Applicant abandoned the '576 Application. *See id.* at 262–63.

The overlap between the abandoned '576 Application claims found anticipated by Kishi and the '909 Patent claims challenged here is shown below. Claim 9 of the '909 Patent has identical scope to abandoned Claim 11 of the '576 Application and also is plainly anticipated by Kishi.

Rejected Claim 11 of '576 Application Abandoned After Kishi Rejection	**Claim 9 of '909 Patent Challenged Here**
11. (New) A magnetoresistive device comprising a magnetic tunnel junction structure comprising:	9. A magnetoresistive device comprising a magnetic tunnel junction structure comprising:
a first ferromagnetic material layer;	first and second ferromagnetic material layer; and
a second ferromagnetic material layer; and	
a tunnel barrier layer between the first ferromagnetic material layer and the second ferromagnetic material layer,	a tunnel barrier layer between the first and second ferromagnetic material layers,
wherein said tunnel barrier layer comprises magnesium oxide and has a barrier height in a range of 0.1 eV to 0.85 eV.	wherein said tunnel barrier layer comprises magnesium oxide and has a barrier height in a range of 0.1 eV to 0.85 eV.
Ex. 6 at 83 (rejected and abandoned Claim 11); *id.* at 262–63 (Notice of Abandonment).	Ex. 1 at 10:26–33 (Claim 9).

As explained in this reexamination request, the claims of the '909 Patent are anticipated and rendered obvious by Kishi (Ex. 4). The claims are also rendered obvious by Parkin in view of Kishi (Exs. 4–5). Reexamination is warranted because the Office has not examined the claims of the '909 Patent in view of Kishi or the combination of Parkin and Kishi presented here.

II. CERTIFICATIONS

Pursuant to 37 C.F.R. § 1.510(b)(5), Requestor certifies that a copy of this Request has been served in its entirety on the Patent Owner at the address as provided for in § 1.33(c):

Wolf Greenfield & Sacks, P.C.
600 Atlantic Ave.
Boston, MA 02210-2206

Pursuant to 37 C.F.R. § 1.510(b)(6), Requestor certifies that the statutory estoppel provisions of neither 35 U.S.C. § 315(e)(1) nor 35 U.S.C. § 325(e)(1) prohibit Requestor from filing this Request.

III. 37 C.F.R. § 1.565 NOTIFICATION

The '909 Patent currently is the subject of the following pending matters which have not entered final judgment regarding the validity of the '909 Patent:

- IPR2024-01494;
- *Godo Kaisha IP Bridge 1 v. Seagate Technology*, No. 24-cv-03691 (D. Minn); and
- *Godo Kaisha IP Bridge 1 v. Western Digital Technologies*, No. 24-cv-06555-RS (N.D. Cal.).

IV. CLAIMS FOR WHICH REEXAMINATION IS REQUESTED

Patent Owner has already disclaimed Claims 1–4 and 7–8 of the '909 Patent. Ex. 3. Accordingly, reexamination is requested for remaining Claims 5–6 and 9–20 of the '909 Patent.

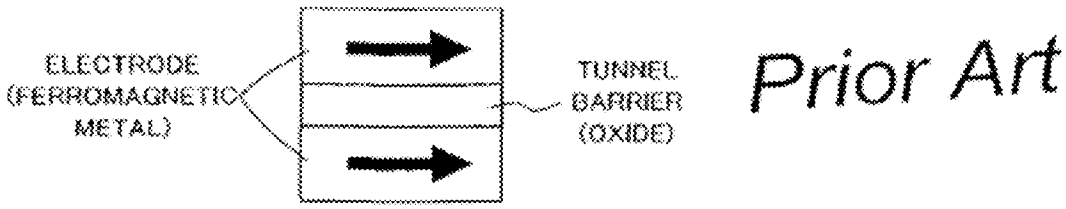
V. OVERVIEW OF THE '909 PATENT

All claims of the '909 Patent have an effective filing date before March 16, 2013, and therefore, it is governed by pre-AIA 35 U.S.C. §§ 102 and 103. MPEP § 2159 ; *see also* Pub. L. No. 112–29 at § 3(n); 125 Stat. at 293.

The '909 Patent claims priority as a continuation of PCT/JP2005/004720 filed March 10, 2005, which in turn claims priority to two Japanese patent applications filed March 12 and October

28, 2004. Ex. 13 (Patent family tree). Under pre-AIA law, the patent's 35 U.S.C. § 102(b) critical date is March 10, 2004. MPEP § 2151 ("Under pre-AIA 35 U.S.C. 102(b), the one-year [bar] is measured from the filing date of the earliest application filed in the United States (directly or through the PCT) and not from the dates of earlier filed foreign patent applications."); *Group One v. Hallmark Cards*, 254 F.3d 1041, 1044-45 (Fed. Cir. 2001) ("Under 35 U.S.C. § 363, the United States filing date, for § 102(b) purposes, of a patent application filed under the PCT in which the United States is designated, is the date of the PCT application….").

FIG. 8 (A)



The '909 Patent describes and claims "magnetic tunnel junction[s]" (MTJs). Ex. 1 at 1:51–54. As illustrated in Figure 8(A) reproduced above, the basic structure of an MTJ is a sandwich comprising an insulating barrier layer between conducting ferromagnetic layers. *Id.* at Fig. 8(A), 1:54–58. The patent acknowledges that MTJs were well known in the art. *Id.* at 1:51–2:9, Figs. 8(A)-(B) (describing MTJ structure as "Prior Art").

In an MTJ, electrical current flows through the thin, insulating tunnel-barrier layer by quantum mechanical tunneling. When the ferromagnetic layers are magnetically aligned in a parallel fashion, the MTJ exhibits less resistance to tunneling than when the ferromagnetic layers are aligned in an antiparallel fashion. Ex. 1 at 1:60–2:4. The different resistances based on the magnetic alignment of the ferromagnetic layers allows for encoding of digital information ("0"

and "1") by the MTJ. *Id.* at 2:4–7. The ratio of the difference in resistances between the parallel and antiparallel states is called the "tunneling magnetoresistance" (TMR), Ex. 5 ¶ 4, also referred to as the "magnetoresistance (MR) ratio", Ex. 1 at 5:10–16; Ex. 4 ¶ 21 ("magnetoresistive-effect (MR)").

The '909 Patent also discusses "the height of the tunnel barrier," which is the difference between the energy level of the insulating layer's conduction band and the adjacent electrode's Fermi energy. Ex. 1 at 3:24–28, 4:2–6. Tunnel barrier heights were also well known in the prior art. *Id.* at 7:26–28 (noting "experimental values of 0.9" eV for an MgO tunnel barrier); Ex. 2 at 151 ('909 Patent Examiner: "the prior art shows a barrier height of .9ev").

The MTJs of the '909 Patent use a magnesium oxide (MgO) tunnel barrier layer. Ex. 1 at 3:11–14. The patent's MgO barrier layer and its adjacent ferromagnetic layers can be crystalline and (001)-oriented. *Id.* at 3:5–32. MgO(001) has a cubic crystalline lattice making the (001), (010), and (100) crystalline planes equivalent. *Id.* at 4:52–54. (001)-oriented MgO and ferromagnetic barriers were also well known in the prior art. *E.g.*, Ex. 4 ¶ 32 (MgO barrier layers); Ex. 5 ¶ 74 ("Thermal annealing may also improve the crystallographic texture of the MgO layer 120' and the surrounding [ferromagnetic] layers, so that … the crystallographic texture becomes substantially (100) oriented.").

VI. CLAIM CONSTRUCTION

Because the '909 Patent has expired, its claims are interpreted according to the same principles used in federal court. *In re Rambus*, 694 F.3d 42, 46 (Fed. Cir. 2012) (citing MPEP § 2258(I)(G)); *see also* MPEP § 2240; *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005).

None of the claim terms of the '909 Patent requires construction for purposes of this Request and may be accorded their "ordinary and customary meaning." *O2 Micro Int'l v. Beyond*

Innovation Tech., 521 F.3d 1351, 1362–63 (Fed. Cir. 2008) ("[C]ourts are not (and should not be) required to construe *every* limitation present in a patent's asserted claims" but only as necessary to resolve "disputed meanings and technical scope." (internal citations omitted)).

VII. PRIOR ART REFERENCES

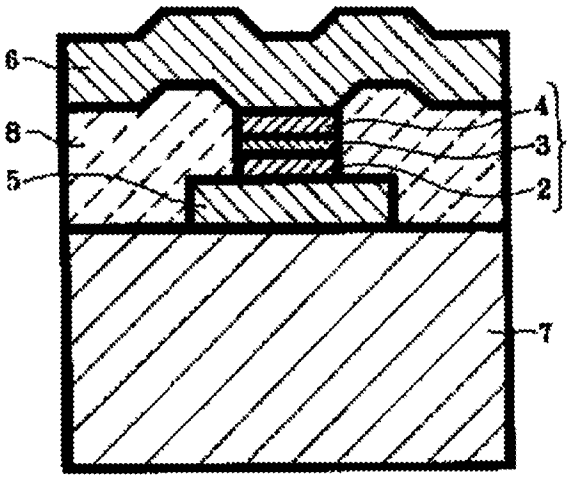
A. Kishi (Ex. 4)

Japanese Patent Application No. 2000-106462 to Kishi et al. (Ex. 4, "Kishi") was published April 11, 2000. Ex. 4 at 1, [43]. Kishi is prior art because it was published before the March 10, 2004 critical date for the '909 Patent. *Supra* § V.

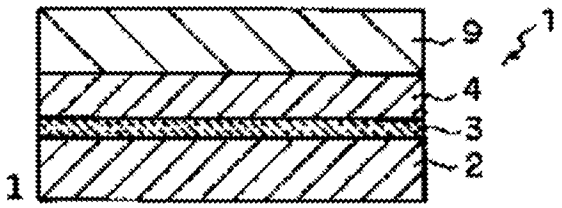
Kishi was not cited during examination of the '909 Patent and is not before the Office in the pending *inter partes* review of the patent. *See* Exs. 2, 10.

Kishi concerns MTJs. Ex. 4 at Abstract ("(MEANS FOR SOLVING) A magnetic element utilizing tunnel resistance…."). Like the '909 Patent, Kishi's MTJ is a typical ferromagnetic layer—insulating barrier—ferromagnetic layer stack, as illustrated in Figures 1 and 2 reproduced below with reference to first ferromagnetic layer 2, tunnel barrier layer 3, and second ferromagnetic layer 4. Ex. 4 ¶¶ 20-21 (FIGURE 1), 24 (FIGURE 2).

(FIGURE 1)



(FIGURE 2)



"There are no particular restrictions on the constituent material of first and second ferromagnetic layers 2 and 4" in Kishi. Ex. 4 ¶ 23. For example, the first and second ferromagnetic layers may be iron (Fe) or an alloy of iron and cobalt (CoFe). *Id.* Kishi teaches MgO barrier layers and barriers made from other "insulators [] with small gaps." *Id.* ¶¶ 31–32.

Kishi discloses a computed value "$S/(\phi)^{1/2}$" where S is the tunnel barrier width (thickness) in units of Angstroms (Å) and ϕ is the tunnel barrier height in units of electron-volts (eV). Ex. 4 ¶ 49. According to Kishi, where $10 \leq S/(\phi)^{1/2}$, the MTJ will exhibit desirable behaviors including an increase in MR with application of bias voltage and decreased MR sensitivity to an increase in temperature. *Id.* ¶¶ 49–50.

Kishi provides data for exemplary MTJs in TABLE 1. Ex. 4 ¶ 93. Sample 9 is an MTJ with CoNi and CoFeNi ferromagnetic layers and an MgO barrier layer. *Id.* The barrier layer is 2 nm thick (20 Å) and the MTJ has a $S/(\phi)^{1/2}$ value of 39. *Id.* Rearranging this equation results in $\phi = (S/39)^2$. Thus, one of ordinary skill in the art would understand that Sample 9 has a barrier height (ϕ) of 0.26 eV ($(20/39)^2 = 0.26$). Kishi thus discloses to skilled practitioners that Sample 9 has a tunnel barrier height of 0.26 eV.

B. Parkin (Ex. 5)

U.S. Patent Application Publication No. 2009/0324814 to Parkin (Ex. 5, "Parkin") claims priority through a series of intervening applications to U.S. Patent Application Serial No. 10/646,246 filed August 22, 2003. Ex. 5 ¶ 1. Exhibit 7 is a copy of the '246 Application File History (Ex. 7, "'246 Application"). All of the subject matter relied upon in this Request to show invalidity is also parallel-cited in the '246 Application, proving that Parkin is entitled to priority to the '246 Application for the entirety of the subject matter relied upon in this Request.

Additionally, at least Claim 1 of Parkin is entitled to priority to the '246 Application. The table below shows where the subject matter of each limitation of Parkin's Claim 1 can be found in original claims in Parkin's '246 Application, proving written description support exists for Claim 1 in the '246 Application and confirming that Parkin is entitled to the August 22, 2003 priority date of the '246 Application for the cited subject matter. *See In re Riggs*, 131 F.4th 1377, 1384–85 (Fed. Cir. 2025).

Claim 1 of Parkin (Ex. 5)	Parkin's '246 Application (Ex. 7)
1[preamble] A method, comprising:	Claim 1 of the application recites: "A method, comprising: …." Ex. 7 at 50:3.
1[a] **depositing Mg onto a surface of an underlayer to form a Mg layer thereon, wherein the surface is selected to be substantially free of oxide**, and the underlayer includes at least one layer of magnetic material selected from the group consisting of ferromagnetic materials and ferrimagnetic materials;	Claim 1 of the application recites: "**depositing Mg onto a surface of an underlayer to form a Mg layer thereon, wherein the surface is selected to be substantially free of oxide**; …." Ex. 7 at 50:4–5. Additionally, Claim 17 recites, "The method of Claim 1, wherein the underlayer includes a ferrimagnetic material." *Id.* at 51:14. And Claim 20 recites, "The method of Claim 1, wherein the underlayer includes a ferromagnetic material." *Id.* at 51:19.
1[b] **directing additional Mg, in the presence of oxygen, towards the Mg layer to form a MgO tunnel barrier in contact with the underlayer, the**	Claim 1 of the application recites: "**directing additional Mg in the presence of oxygen, towards the Mg layer to form a MgO tunnel barrier in contact with the underlayer, the**

Claim 1 of Parkin (Ex. 5)	Parkin's '246 Application (Ex. 7)
oxygen reacting with the additional Mg and the Mg layer;	**oxygen reacting with the additional Mg and the Mg layer**." Ex. 7 at 50:6–8.
1[c] **forming an overlayer on the MgO tunnel barrier to form a magnetic tunnel junction, wherein the overlayer includes a magnetic material selected from the group of materials consisting of ferromagnetic materials** and ferrimagnetic materials; and	Claim 26 of the application recites: "The method of Claim 20, **further comprising forming an overlayer on the MgO tunnel barrier to form a magnetic tunnel junction, wherein the overlayer includes a ferromagnetic material.**" Ex. 7 at 52:7–9. Claim 19 of the application recites: "The method of Claim 1, further comprising forming an overlayer on the MgO tunnel barrier, wherein the overlayer includes a ferrimagnetic material." *Id.* at 51:17–18.
1[d] **annealing the tunnel junction to yield a tunnel magnetoresistance of greater than 100% at room temperature**.	Claim 28 of the application recites: "The method of Claim 26, further comprising **annealing the tunnel junction to increase its tunnel magnetoresistance**." Ex. 7 at 52:12–13. Claim 29 of the application recites: "The method of Claim 28, wherein the tunnel junction is annealed **at a temperature selected to yield a tunnel magnetoresistance of greater than 100% at room temperature**." *Id.* at 52:14–15.

Parkin is thus prior art to the '909 Patent because it is "an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent…." 35 U.S.C. § 102(e). Although Parkin was cited during prosecution of the '909 Patent among a long list of art submitted in an IDS and considered by the Examiner, it was not relied upon for any rejection or discussed during prosecution. Ex. 2 at 19 (IDS citing Parkin). Indeed, the prosecution involved only a single prior art rejection that was overcome on the basis that "Debrosse et al. (US2004/0109347) fails to disclose a tunnel barrier made of MgO with a barrier height between 0.1eV to 0.85eV." Ex. 2 at 163.

Parkin by contrast does disclose magnetic tunnel junctions with MgO barriers: "More particularly, this invention relates to a method of forming a MgO tunnel barrier to allow for MTJ devices with significantly improved magnetoresistance." Ex. 5 ¶ 3; Ex. 7 at 3:7–9. Parkin's Figure 2B reflects its invention in which a lower ferromagnetic layer 115, a tunnel barrier layer 120', and an upper ferromagnetic layer 134 form a magnetic tunnel junction. Ex. 5 ¶ 52, Fig. 2B; Ex. 7 at 27:4–28:5, Fig. 2B. Parkin's tunnel barrier layer 120' is a single layer of MgO. Ex. 5 ¶ 52; Ex. 7 at 27:12–15.

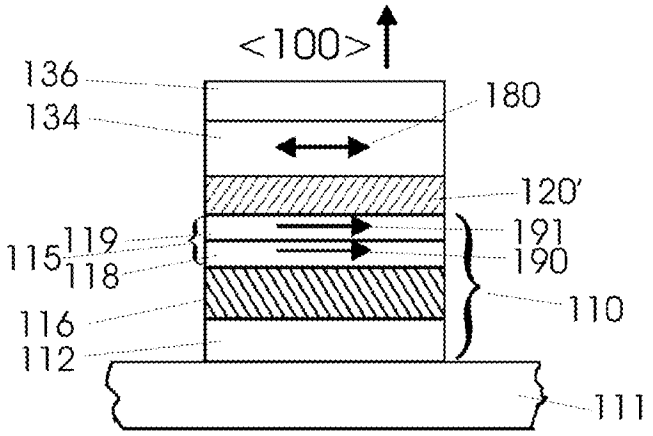


FIG. 2B

Ex. 5, Fig. 2B. Parkin's MTJ includes both ferromagnetic layers and a tunnel barrier layer that are crystalline and grown in the (100) orientation. Ex. 5 ¶ 57; Ex. 7 at 17:15–22, 30:21–31:4; *see also* Ex. 5 ¶ 74 ("Thermal annealing may also improve the ***crystallographic texture of the MgO layer 120' and the surrounding layers***, so that the structure prior to annealing may not be substantially (100) oriented but after thermal anneal treatments in the temperature range described above the crystallographic texture becomes substantially (100) oriented." (emphasis added)); Ex. 7 at 42:22–43:3 (same).

Parkin further teaches that its MgO layer in its MTJs "will become partially or completely oxidized, depending on the oxidation conditions and the thickness of the Mg layer 122," such that Parkin's MgO layer may be less than completely oxidized. Ex. 5 ¶ 63; Ex. 7 at 35:11–13.

VIII. STATEMENT POINTING OUT EACH SUBSTANTIAL NEW QUESTION OF PATENTABILITY FOR THE CHALLENGED CLAIMS

A question raised by the prior art is substantial when "there is a substantial likelihood that a reasonable examiner would consider the prior art [] important in deciding whether or not the claim is patentable." MPEP § 2242(I). The question is new when it "has not been decided by the Office in an earlier concluded examination or review of the patent, raised to or by the Office in a pending reexamination or supplemental examination of the patent, or decided in a final holding of invalidity (after all appeals) by a federal court in a decision on the merits involving the claim." *Id.*

The '909 Patent was issued by the Office based on its purportedly distinguishing "0.1 eV to 0.85 eV" and "0.2 eV to 0.5 eV" barrier height limitations. Ex. 2 at 163. Kishi teaches these limitations and has not been raised to or by the Office during examination or review of the patent.

A. Examination Of The '909 Patent

Claims 5–6 and 9–20 of the '909 Patent to which this Request pertains were introduced in a preliminary amendment concurrent with the filing of the application for patent and were amended before substantive examination began. Ex. 2 at 63–66 (July 7, 2023 Preliminary Amendment); Ex. 2 at 95–97 (Aug. 9, 2023 Preliminary Amendment).

The Examiner subsequently rejected all the pending claims on the basis of an obviousness combination of U.S. Patent App. Pub. No. 2004/0109347 to DeBrosse and U.S. Patent App. Pub. No. 2004/0109347 to Sharma. Ex. 2 at 107 (Jan. 25, 2024 Office Action). The Examiner interpreted DeBrosse as disclosing a tunnel barrier layer with "a barrier height in a range of .1eV to .85eV or .2eV to .5eV," thus disclosing the barrier height limitations. *Id.* at 107–108.

Nevertheless, in a later interview the Examiner agreed with the applicant that DeBrosse "fails to disclose a tunnel barrier… with a barrier height between .1eV to .85eV" because its barrier height (".9eV") fell just outside the claimed range. Ex. 2 at 151 (Interview Summary). And in a later response to the January 25 Office Action, the applicant further argued that Sharma also failed to "disclose… a tunnel barrier made of MgO with a barrier height between 0.1eV to 0.85eV." Ex. 2 at 164 (Feb. 29, 2024 Response).

The Examiner accepted the applicant's arguments at face value. In its subsequent Notice of Allowance, the Examiner stated that the subject matters of independent Claims 9 and 15 were allowable based solely on the barrier height limitations. Ex. 2 at 170 (referencing filed Claim 11 [issued Claim 9] and filed Claim 17 [issued Claim 15]). The '909 Patent issued April 23, 2024.

B. The Office Rejects Claims In The Child '576 Application Over Kishi And Applicant Affirmatively Abandons The Application

During prosecution of the '909 Patent, the applicant filed a child continuation application claiming priority to the '909 Patent: App. No. 18/232,576 ("the '576 Application). Ex. 13 (Patent family tree); Ex. 6 at 78 (Amendments to the Specification introducing claim of priority to App. No. 18/219,320—the '909 Patent). The '576 Application was examined by the same Examiner that examined the '909 Patent. *Compare* Ex. 1 at 1, [56] ("Primary Examiner – Alonzo Chambliss"), *with* Ex. 6 at 183 (Office Action: Examiner Alonzo Chambliss), *id.* at 263 (Notice of Abandonment: Examiner Alonzo Chambliss).

In the '576 Application, Applicant filed a preliminary amendment with essentially identical claims to those allowed in the '909 Patent, including claims reciting "0.1 eV to 0.85 eV" and "0.2 eV to 0.5 eV" barrier heights. Ex. 6 at 82–84. A comparison of an exemplary claim of the '576 Application and the '909 Patent is shown below:

Claim 11 of '576 Application Abandoned After Kishi Rejection	**Claim 9 of '909 Patent Challenged Here**
11. (New) A magnetoresistive device comprising a magnetic tunnel junction structure comprising:	9. A magnetoresistive device comprising a magnetic tunnel junction structure comprising:
a first ferromagnetic material layer;	first and second ferromagnetic material layer, and
a second ferromagnetic material layer; and	
a tunnel barrier layer between the first ferromagnetic material layer and the second ferromagnetic material layer,	a tunnel barrier layer between the first and second ferromagnetic material layers,
wherein said tunnel barrier layer comprises magnesium oxide and has a barrier height in a range of 0.1 eV to 0.85 eV.	wherein said tunnel barrier layer comprises magnesium oxide and has a barrier height in a range of 0.1 eV to 0.85 eV.
Ex. 6 at 83 (rejected and abandoned Claim 11); *id.* at 262–63 (Notice of Abandonment).	Ex. 1 at 9:27–34 ('909 Patent Claim 9).

After initially allowing the claims in the '576 Application, the Examiner withdrew them from issue. Ex. 6 at 214–20 (Nov. 6, 2023 Notice of Allowability); *id.* at 227–29 (Jun. 12, 2024 Withdrawal). Just two months after the '909 Patent issued, the Examiner proceeded to reject pending Claims 11–22 as anticipated and obvious over Kishi. *Id.* at 254–61 (Jun. 26, 2024 Office Action)). He found "Kishi teaches a barrier height of (0.1 eV to 0.85 eV) and (.2eV to .5eV)" required by the claims. *Id.* at 257. These are the same barrier height limitations that the Examiner found merited allowance on the parent '909 Patent challenged here. *See* Ex. 2 at 170.

Applicant did not respond. When the Examiner contacted Applicant's counsel, he "informed the examiner on 1/3/2025 that the case has gone abandon[ed]." Ex. 6 at 262–63 (Jan. 14, 2025 Notice of Abandonment).

C. IPR Challenging '909 Patent

Requestor filed an IPR Petition challenging the '909 Patent claims on September 27, 2024, before Patent Owner abandoned the '576 Application over Kishi. The Patent Trial and Appeal Board instituted the IPR on April 30, 2025. Institution Decision (Ex. 10). Kishi is not part of any IPR ground and is not being considered by the Board. Ex. 10 at 6–7. The IPR remains pending, and no Final Written Decision has issued.

During the '909 Patent IPR, Patent Owner argued its claims are patentable because the prior art does not disclose the claimed 0.1 eV to 0.85 eV and 0.2 eV to 0.5 eV barrier heights and fails to provide a motivation to apply any disclosed barrier heights to prior art MgO barrier layers. Its arguments are flatly contradicted by Kishi's disclosure of exactly that and Patent Owner's conduct abandoning its continuation of the '909 Patent. Ex. 4 ¶¶ 50, 93 (Sample 9); Ex. 6 at 262–63.

For example, Patent Owner has argued:

- "Every Challenged Claim requires a tunnel barrier layer comprising… a barrier height of 0.1-0.85 eV [] or 0.2-0.5 eV…. Soukup's alleged barrier height of 0.33 eV is the only barrier height value Petitioner alleges…." Ex. 11 at 30 (emphasis omitted).
- "Petitioner's assertion that Soukup would have motivated a POSA [person of ordinary skill in the art] to adopt a barrier height of 0.33 eV in Bowen and Nagahama fails because Petitioner establishes no reason why a POSA would have done so." Ex. 11 at 31.
- "Petitioner could not find an MTJ device with an MgO barrier layer and a tunnel barrier height within either claimed range." Ex. 11 at 58.
- "A POSA would not have made any modification to Bowen or Nagahama in an attempt to achieve a barrier height value of 0.33 eV that a POSA knew was wrong." Ex. 11 at 67.

- "Petitioner points to no reference describing a device with a TMR that discloses a barrier height of 0.33 eV…." Patent Owner Sur-Reply (Ex. 12) at 20.

- "Soukup's 0.33 eV Value Was Inaccurate." Ex. 12 at 22.

Patent Owner's decision to defend the '909 Patent claims based on its recitation of specific tunnel barrier heights further demonstrates its claims are unpatentable.

D. Kishi Raises Substantial New Questions of Patentability Regarding Whether Claims 9, 15, and 20 Are Novel And Non-obvious

Kishi alone raises substantial questions regarding the patentability of Claims 9, 15, and 20 of the '909 Patent. Patent Owner abandoned nearly identical claims in the child '576 Application after the same Examiner found those claims anticipated Kishi. Ex. 6 at 257, 263; *supra* § VIII.B. Kishi explicitly discloses an MTJ with an MgO barrier layer having a barrier height of 0.26 eV, thus anticipating the "0.1 eV to 0.85 eV" and "0.2 eV to 0.5 eV" barrier height limitations. Ex. 4 ¶ 49 (formula for "$S/(\phi)^{1/2}$"), ¶ 93 (Table 1 teaching barrier height of 0.26 eV for Sample 9 via disclosed thickness and $S/(\phi)^{1/2}$ values). Kishi therefore discloses the barrier height limitations the patentee and current Patent Owner have relied upon throughout examination and IPR to distinguish the patent from the prior art. This alone indicates that the patentability questions raised by Kishi are substantial. Further, Kishi discloses all the other limitations of Claims 9, 15, and 20, thus anticipating those claims as well. A reasonable examiner would therefore consider Kishi to be important in deciding the patentability of the claims of the '909 Patent. MPEP § 2242. And the same Examiner for the '909 Patent in fact rejected claims of identical scope in the child '576 Application over the Kishi prior art. Ex. 6 at 257-60.

The substantial questions regarding the novelty of Claims 9, 15, and 20 of the '909 Patent raised by Kishi are all new to the Office. Kishi was not cited during examination of the '909 Patent and therefore was not relied upon by the Office in any capacity whatsoever in assessing the

patentability of the examined claims. And with respect to the art that *was* cited, according to the Examiner, "none of the prior art of record" in the patent "teach[es] or suggest[s]" "a barrier height in a range of 0.1 eV to 0.85 eV." Ex. 2 at 170 (Notice of Allowability). Kishi teaches both the broader 0.1 eV to 0.85 eV and the narrower 0.2 eV to 0.5 eV barrier height limitations and is therefore not cumulative of the prior art considered during the original examination.

Nor has Kishi been asserted in the *inter partes* review of the '909 Patent. With respect to the art that has been asserted there to teach the claimed barrier height limitations, the Patent Owner contends that the art is not an MTJ and its reported barrier heights are inaccurate. Ex. 11 at 30 (Patent Owner: "Soukup's alleged barrier height of 0.33 eV is the only barrier height value Petitioner alleges…"), 53 (Patent Owner: "Soukup's devices are not magnetoresistive devices, let alone MTJs."); Ex. 12 at 22 (Patent Owner: "Soukup's 0.33 eV Value Was Inaccurate"), 23–24 (Patent Owner: "Petitioner … offers no reason why POSAs would have credited the 0.33 eV value from the Arrhenius plot method Soukup says was suspect over the 0.714 eV zero-intercept value."). In comparison to the Patent Owner's arguments during *inter partes* review, there is no doubt here that Kishi discloses an MTJ. Ex. 4 ¶ 11 ("The magnetic element according to the present invention is characterized by the fact that it has a ferromagnetic tunnel junction…."). Nor is there any reason to doubt the veracity of its barrier height teachings. *Id.* ¶¶ 49–50, 93 (TABLE 1, esp. Sample 9). Kishi therefore is not cumulative to the prior art cited during *inter partes* review of the patent should the Patent Owner's arguments about the prior art asserted there be accepted.

E. Parkin In View Of Kishi Raises Substantial New Questions Of Patentability Regarding Whether Claims 5–6 and 9–20 Are Non-obvious

Parkin in view of Kishi also raises substantial questions regarding the patentability of claims 5–6 and 9–20 of the '909 Patent. As explained in this request, Parkin discloses all the limitations of these claims save the "0.1 eV to 0.85 eV" and "0.2 eV to 0.5 eV" barrier height

limitations. Kishi, however, discloses an MTJ with an MgO barrier layer having a barrier height of 0.26 eV. Ex. 4 ¶¶ 49 (formula for "$S/(\phi)^{1/2}$"), 93 (TABLE 1 teaching barrier height of 0.26 eV for Sample 9 via disclosed thickness and $S/(\phi)^{1/2}$ values). Moreover, Kishi's preferred $S/(\phi)^{1/2}$ ranges, in combination with Parkin's preferred barrier layer thicknesses, further disclose barrier height ranges that overlap with the claimed "0.1 eV to 0.85 eV" and "0.2 eV to 0.5 eV" ranges. Skilled artisans would have been motivated to combine Parkin with Kishi, rendering obvious Claims 5–6 and 9–20. A reasonable examiner would therefore consider Parkin combined with Kishi to be important in deciding the patentability of the claims of the '909 Patent. MPEP § 2242.

The substantial questions regarding the obviousness of Claims 5–6 and 9–20 of the '909 Patent raised by Parkin in view of Kishi are all new to the Office. "[A] substantial new question of patentability can be raised by patents and printed publications previously cited by or to the Office or considered by the Office." MPEP § 2216 (internal quotations omitted). This includes if "if the reference is presented in a new light or a different way that escaped review during earlier examination." *Id.* The Parkin prior art was never relied upon substantively for any claim rejections and was merely cited by applicant among hundreds of other items in an Information Disclosure Statement. Ex. 2 at 19; *see id.* at 3–27 (July 7, 2023 IDS). Parkin is additionally presented in a new light here because it is combined with Kishi, which was not before the Office during the original examination of the '909 Patent.

IX. DETAILED EXPLANATION OF THE PERTINENCE AND MANNER OF APPLYING THE PRIOR ART REFERENCES TO EVERY CLAIM FOR WHICH REEXAMINATION IS REQUESTED

A. Anticipation Over Kishi

Claims 9, 15, and 20 of the '909 patent each are anticipated by Kishi.

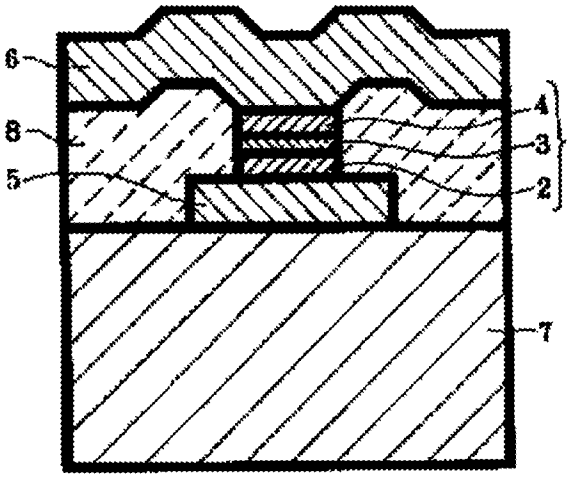
1. Claim 9

Claim 9 is anticipated by Kishi.

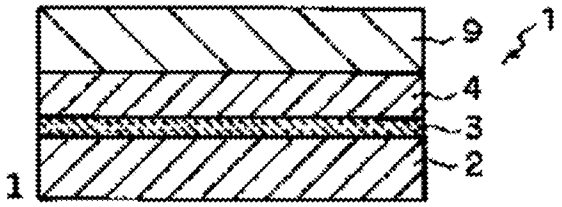
a. Claim 9[preamble]: "A magnetoresistive device comprising a magnetic tunnel junction structure comprising:"

To the extent the preamble is limiting, Kishi teaches a magnetoresistive device with a magnetic tunnel junction structure, as claimed. Ex. 4 at Abstract ("(MEANS FOR SOLVING) A magnetic element utilizing tunnel resistance..."), ¶ 11 ("(MEANS FOR SOLVING THE PROBLEM) The magnetic element according to the present invention is characterized by the fact that it has a ferromagnetic tunnel junction constructed of laminated film of at least two layers of a ferromagnetic layer and at least one layer of a tunnel barrier layer that is interposed between said two ferromagnetic layers ...."). The multi-layer material stack of Kishi's MTJ is illustrated in Figures 1 and 2, including "ferromagnetic layers 2 and 4" and "tunnel barrier layer 3." *Id.* ¶¶ 20–21.

(FIGURE 1)



(FIGURE 2)



Kishi provides various examples of "ferromagnetic tunnel junctions" in TABLE 1, confirming that the devices in Table 1 have magnetic tunnel junction structures. Ex. 4 ¶ 92; *see also id.* ¶ 93 (labeling column 2 as a description of each sample's "Ferromagnetic tunnel junction structure"). One such example is Sample 9. *Id.* ¶ 93. Kishi's Sample 9 includes a lower

ferromagnetic layer made of $Co_{85}Ni_{15}$, a tunnel barrier layer of MgO, and an upper ferromagnetic layer made of Co_7Fe_2Ni and NiMn. *Id.* Sample 9 is a magnetoresistive device as disclosed by Kishi because Kishi reports the ratio of MR (380 K)/MR (280 K) of 0.97, confirming that this MTJ exhibits magnetoresistive properties. *Id.* ¶¶ 49–50, 92–93. Thus, Sample 9 discloses Claim 9[preamble].

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

Kishi's Sample 9 has first and second ferromagnetic layers as described in Claim 9[preamble] and shown in Table 1. *See* Ex. 4 ¶ 93. Kishi's TABLE 1 description of the "Ferromagnetic tunnel junction structure" describes the layers in that tunnel junction structure starting at the bottom of the structure and describing each successive layer up to the top of the MTJ. *Id.* Thus, Kishi's structure description of Sample 9 as "Co85Ni15 (10) / MgO (2) / Co7Fe2Ni (4) / NiMn (20)" means that Kishi's Sample 9 includes a lower ferromagnetic layer made of $Co_{85}Ni_{15}$, a tunnel barrier layer of MgO on top of the $Co_{85}Ni_{15}$ ferromagnetic layer, and an upper ferromagnetic layer made of Co_7Fe_2Ni and NiMn on top of the MgO tunnel barrier layer. *Id.* As Kishi explains in TABLE 1, the parenthetical numbers following each layer "indicate thickness" of the layer in nanometers. *Id.*

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

Kishi's Sample 9 includes a tunnel barrier layer of MgO between the two ferromagnetic layers as described in Claim 9[preamble] and Claim 9[a]. Ex. 4 ¶ 93.

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

Kishi's Sample 9 includes a tunnel barrier layer that comprises MgO as discussed above in Claims 9[preamble], 9[a], and 9[b]. Ex. 4 ¶ 93.

Kishi teaches that the tunnel barrier layer of Sample 9 has a barrier height in the claimed range. Kishi teaches a computed value $S/(\phi)^{1/2}$ where S is the physical width (thickness) of the tunnel barrier layer (in Angstroms) and ϕ is the tunnel barrier height (in eV). Ex. 4 ¶ 49. With respect to Sample 9, Kishi reports $S/(\phi)^{1/2}$ of 39 and barrier thickness (S) of 2 nm (20 Å). Rearranging this equation results in $\phi = (S/39)^2$. *Id.* ¶ 93. Thus, one of ordinary skill in the art would understand that Sample 9 has a barrier height (ϕ) of 0.26 eV ($(20/39)^2 = 0.26$). Kishi's Sample 9 barrier height of 0.26 eV is in a range of 0.1 eV to 0.85 eV.

2. Claim 15

Claim 15 is anticipated by Kishi.

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

Supra Claim 9[preamble].

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

Supra Claim 9[a].

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

Supra Claim 9[c]. The taught barrier height of Sample 9 (0.26 eV) falls within the claimed range of 0.2 eV to 0.5 eV. *See* Ex. 4 ¶ 93.

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

Supra Claim 9[a]. Given Kishi's Sample 9 stack structure of $Co_{85}Ni_{15}$—MgO— Co_7Fe_2Ni and NiMn, Kishi's second ferromagnetic material layer (Co_7Fe_2Ni and NiMn) is disposed on the tunnel barrier layer (MgO) and is separated from the first ferromagnetic material layer ($Co_{85}Ni_{15}$) by the tunnel barrier layer. Ex. 4 ¶ 93.

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

Claim 20 is anticipated by Kishi.

Kishi reports that Sample 9's tunnel barrier has a thickness of 2 nm. Ex. 4 ¶ 93 ("MgO (2)"); *see also id.* (explaining that the parentheticals following each layer "indicate thickness" of the layer in nanometers). This thickness falls within the claimed range of less than 10 nm.

B. Obviousness Over Parkin In View Of Kishi

Claims 5–6 and 9–20 of the '909 Patent are invalid as obvious over Parkin in view of Kishi.

1. Motivation To Combine And Reasonable Expectation Of Success

Parkin teaches an MTJ with an MgO tunnel barrier and a specific method of manufacturing the MgO barrier such that the formation of the MgO can be carefully controlled to avoid oxidation of the underlying ferromagnetic electrode. Ex. 5 ¶ 52; Ex. 7 at 27:4–7. Parkin's MTJ is formed of ferromagnetic layers that "are both bcc and at least substantially (100) oriented." Ex. 5 ¶ 22; Ex. 7 at 17:15–22 (describing both ferromagnetic layers as "substantially (100) oriented"). Likewise, Parkin's "MgO tunnel barrier is preferably at least substantially (100) oriented." Ex. 5 ¶ 22; Ex. 7 at 18:20–23, 19:6–8. An example is shown in Figure 2B, which includes MgO tunnel barrier 120', free ferromagnetic layer 134, and fixed ferromagnetic layer 115. Ex. 5 ¶ 52; Ex. 7 at 27:12–28:5.

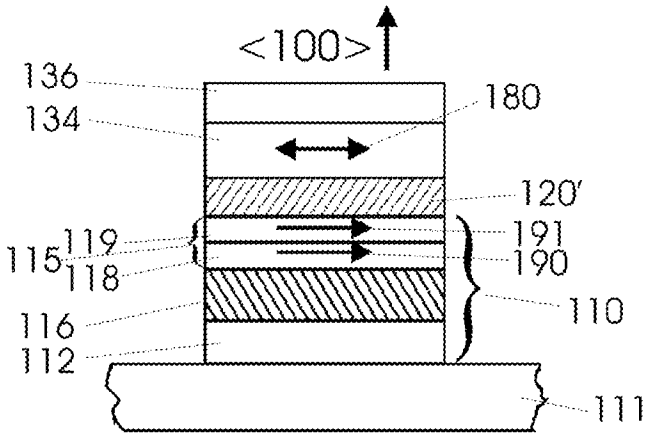


FIG. 2B

Parkin's MTJ achieved very high TMR values, "which can exceed 160% at room temperature." Ex. 5 ¶ 20; Ex. 7 at 16:12–14 (same). Parkin explains that previous theoretical work on MTJs with MgO barriers "assume perfectly formed barriers and interfaces with ferromagnetic electrodes" and that "even small amounts of disorder would render these theoretical predictions moot …." Ex. 5 ¶ 80. However, Parkin observes that "it is quite surprising that the TMR values reported herein for MTJs using MgO tunnel barriers are so high even with the disclosed method of forming these barriers." *Id.* Parkin's method for forming the MgO barrier layer includes forming a first Mg layer and then forming an MgO layer above the Mg layer, which will result in the original Mg layer becoming "partially or completely oxidized, depending on the oxidation conditions and the thickness of the Mg layer 122." Ex. 5 ¶ 63; Ex. 7 at 35:11–13 (same). Thus, Parkin contemplates that the resulting combined MgO layer may have oxygen vacancy defects and yet achieves very high TMR values.

However, Parkin notes that there is a significant dependence of TMR on temperature. Ex. 5 ¶ 71 ("As shown in FIG. 9, the TMR increases significantly as the temperature is lowered and

almost doubles on cooling from 300K to 4K."); Ex. 7 at 40:6–7 (same). As shown in Figure 9 below, TMR drops significantly as temperature increases.

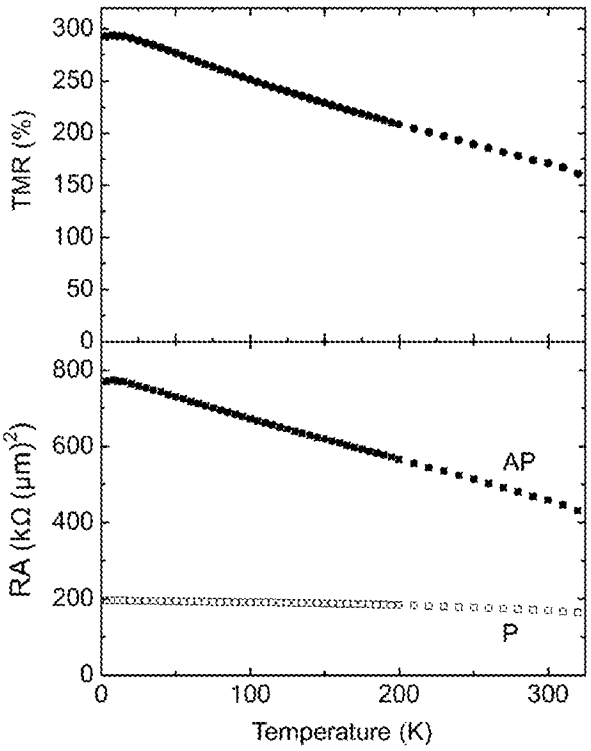


FIG. 9

Ex. 5 at Fig. 9; Ex. 7 at Fig. 9. Parkin does not describe the TMR behavior for his MTJs with increasing bias voltage. But as Kishi reports, "the magneto-resistance ratio in ferromagnetic tunnel junctions depends on the bias voltage, and the problem is that the magneto-resistance ratio decreases as the bias voltage increases." Ex. 4 ¶ 9.

One of skill in the art would be motivated to employ Kishi's teachings to help stabilize TMR and reduce the loss of TMR with bias voltage and increasing temperature by employing Kishi's guidelines for manufacturing. Ex. 4 at Abstract ("(PROBLEM) To reduce the dependence of the magnetoresistance ratio on the bias voltage and temperature…."); *see also id.* ¶ 10. Parkin

discloses significant reduction in TMR with increasing temperature as shown in Figure 9, for example. Thus, one of skill in the art would be motivated to minimize the loss of TMR with bias voltage and increasing temperature as taught by Kishi because, as Parkin taught, "higher TMR values will lead to higher [signal to noise ratio] values for otherwise the same resistance." Ex. 5 ¶ 9; Ex. 7 at 8:6–8 (same). And one of Parkin's goals was "MTJ devices with significantly improved magnetoresistance." Ex. 5 ¶ 3; Ex. 7 at 3:7–9 (same).

Kishi described a "magnetic sensor that can achieve an improvement in the properties and practicality" "by improving the dependence of the magneto-resistive ratio on the bias voltage and the dependence of the magneto-resistive ratio on the temperature …." Ex. 4 ¶ 10. Kishi taught an MTJ with ferromagnetic layers such that "$10 \leq S/(\phi)^{1/2} \leq 40$" where S is the tunnel barrier width in Angstroms and ϕ is the tunnel barrier height in electron volts. *Id.* ¶ 54 (describing benefits as "significantly and consistently inhibit[ing] any reduction in the magneto-resistance ratio associated with an increase in temperature" and "a magneto-resistance ratio that increases with a positive slope relative to an increase in bias voltage…."); *see also id.* ¶ 16. Kishi also provided a more practical example, stating that "when the tunnel barrier width S is 1.0 to 5.0 nm (10 to 50 Angstroms) and the barrier height is 0.3 to 1.0 eV, the value of $S/(\phi)^{1/2}$ corresponds to the range of $10 \leq S/(\phi)^{1/2} \leq 91$ (Angstrom/$(eV)^{1/2}$)." *Id.* ¶ 50.

Kishi also teaches a specific example of MgO MTJ in which the tunnel barrier layer has a barrier height in the foregoing range. As described *supra*, with respect to Sample 9, Kishi reports $S/(\phi)^{1/2}$ of 39 and barrier thickness (S) of 2 nm (20 Å). Ex. 4 ¶ 93, TABLE 1. Rearranging this equation results in $\phi = (S/39)^2$. Thus, one of ordinary skill in the art would understand that Sample 9 has a barrier height (ϕ) of 0.26 eV ($(20/39)^2 = 0.26$). Thus, Kishi also teaches a specific example of MgO MTJ with a barrier height of 0.26 eV.

One of skill in the art would be motivated to apply Kishi's teachings to Parkin's MgO MTJs to improve their performance for TMR with increasing bias voltage and with increasing temperature. Parkin's MTJs are formed by depositing a Mg layer followed by a MgO layer resulting in oxidation of the underlying Mg layer such that a single substantially oxidized MgO layer results. Ex. 5 ¶ 55 ("[E]ffectively a single layer of MgO 120' is formed."); Ex. 7 at 29:20 (same). Parkin discloses that "[t]he thickness of the resulting MgO layer 120' is preferably in the range of 3-50 angstroms, more preferably 3-30 angstroms, still more preferably 3-20 angstroms, and most preferably 4-15 angstroms." Ex. 5 ¶ 55; Ex. 7 at 30:1–3 (same). Taking the upper end of Parkin's most preferable range of 15 Å, one of skill would understand that Kishi's recommended ratio of "$10 \leq S/(\phi)^{1/2} \leq 40$" would result in barrier heights of 0.14 eV to 2.25 eV ($(15/10)^2 = 2.25$ eV and $(15/40)^2 = 0.14$ eV) and that Kishi's additional teaching of barrier heights of 0.3 to 1.0 eV would satisfy the same criteria for a 15 Å tunnel barrier. Similarly, one of skill would understand that Kishi's Sample 9 with a barrier height of 0.26 eV would also accomplish Kishi's goals. Thus, one of skill would be motivated to apply Kishi's teachings to Parkin's MgO MTJs to achieve Kishi's described benefits of improved TMR performance with increasing bias voltage and increasing temperature.

One of skill would have expected success from such teachings because Kishi taught that such benefits were shown and because Kishi explained that "[s]imilar trends were observed when… MgO [was] used as the dielectric layer for the tunnel barrier layer." Ex. 4 ¶¶ 83, 90. Thus, one of skill would have expected Kishi's predicted benefits to apply to Parkin's MgO MTJs. Additionally, because Parkin's MgO MTJs did not rely on perfect crystal structures and instead utilized "partially or completely oxidized" MgO layers, Ex. 5 ¶ 63; Ex. 7. at 35:11–13 (same), one of skill would not have been concerned about employing Kishi's teaching of oxygen vacancy

defects to achieve the lower recommended barrier heights. *See* Ex. 4 ¶ 92 ("By varying the oxidation time and output when forming the tunnel barrier layer, several ferromagnetic tunnel junctions with different $S/(\phi)^{1/2}$ values were prepared.").

2. Claim 5

Claim 5 is obvious over Parkin in view of Kishi.

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

To the extent the preamble is limiting, Parkin in view of Kishi teaches magnetoresistive devices with a magnetic tunnel junction structure comprising a multi-layer material stack, as claimed. As illustrated in Figure 2B, Parkin discloses a magnetoresistive device with multiple layers including MgO tunnel barrier 120', fixed ferromagnetic layer 115, and free ferromagnetic layer 134. Ex. 5 ¶ 52; Ex. 7 at 27:4–28:5. "The MgO tunnel barriers so formed may be used in magnetic tunnel junctions having tunneling magnetoresistance (TMR) values of greater than 100%." Ex. 5 at Abstract; Ex. 7 at 61 (Abstract) (same). In the proposed combination, employing Kishi's teachings of limiting the tunnel barrier height to, for example, 0.3 – 1.0 eV or 0.26 eV as taught by Kishi by controlling oxidation conditions would not change the overall structure of Parkin's device as depicted in Figure 2B.

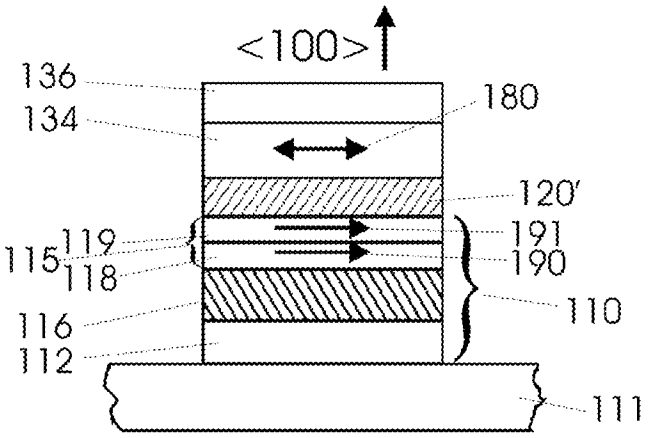


FIG. 2B

Ex. 5 at Fig. 2B; Ex. 7 at Fig. 2B.

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

Parkin in view of Kishi teaches this limitation. As explained in Claim 1[preamble], Parkin's MTJs have multiple layers including fixed ferromagnetic layer 115 and free ferromagnetic layer 134. *E.g.*, Ex. 5 ¶ 52, Fig. 2B; Ex. 7 at 27:4-28:5, Fig. 2B.

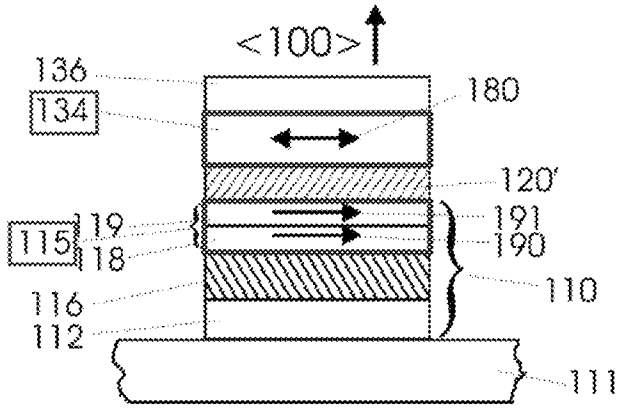


FIG. 2B

Ex. 5 at Fig. 2B (annotated); Ex. 7 at Fig. 2B.

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

Parkin in view of Kishi teaches this limitation. As explained in Claim 1[a], Parkin's MTJs have multiple layers including tunnel barrier layer 120' between fixed ferromagnetic layer 115 and free ferromagnetic layer 134. *E.g.*, Ex. 5 ¶ 52, Fig. 2B; Ex. 7 at 27:4–28:5, Fig. 2B. As depicted, barrier layer 120' is above fixed ferromagnetic layer 115 and below free ferromagnetic layer 134.

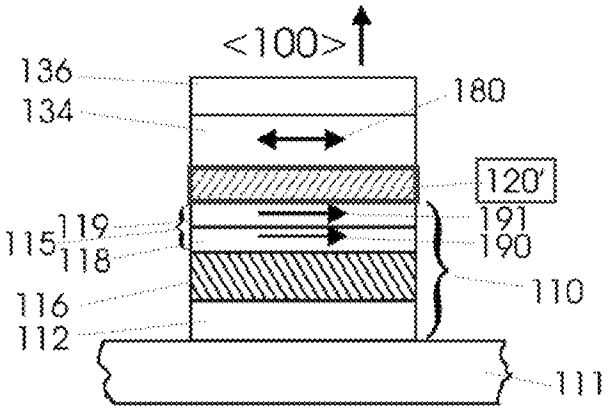


FIG. 2B

Ex. 5 at Fig. 2B (annotated); Ex. 7 at Fig. 2B.

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

Parkin, in view of Kishi, teaches this limitation.

First, Parkin teaches that its tunnel barrier layer is crystalline MgO. *E.g.*, Ex. 5 at 1, [54] ("MgO Tunnel Barriers and Method of Formation"), Abstract ("MgO tunnel barriers are formed by …."), ¶ 74 ("Thermal annealing may also improve the crystallographic texture of the MgO layer 120' and the surrounding layers, so that the structure prior to annealing may not be substantially (100) oriented but after thermal anneal treatments in the temperature range described

above the crystallographic texture becomes substantially (100) oriented."); *see also, e.g.*, Ex. 7 at 61 (Title) (same), Abstract (same)), 42:22–43:3 (same). One of skill understood that in the context of MgO and the ferromagnetic layers, because they have a "cubic crystal structure (NaCl structure), the (001) plane, the (100) plane, and the (010) plane are all equivalent." Ex. 1 at 4:52–60. Thus, Parkin's disclosure of MgO and ferromagnetic layers that are (100) oriented also discloses MgO and ferromagnetic layers that are (001) oriented.

Second, MgO_x where $0<x<1$ is a mathematical notation indicating less than a one-to-one stoichiometric ratio of oxygen to magnesium (*i.e.*, oxygen vacancy defects) in the MgO layer. Ex. 1 at 6:44–46 ("Alternatively, a source with oxygen vacancy defects may be used instead of the MgO of the stoichiometric composition (the ratio of Mg to O is 1:1)."), 7:18–19 ("there is the possibility that there are oxygen vacancy defects such as MgO_x ($0.9<x<1$)"); File History for U.S. Patent No. 7,884,403 (Ex. 8) at 168 (applicant: "MgO_x ($0<x<1$)" means the MgO "crystals have oxygen vacancy defects."). MgO with oxygen vacancy defects can be mathematically notated as MgO_x where $0<x<1$ because x has to be greater than 0 to constitute MgO and less than 1 to constitute nonstoichiometric MgO with oxygen vacancies.

Parkin also discloses that its MgO tunnel barrier may have oxygen vacancy defects. Parkin explains that "[d]uring the deposition of the layer 124, the Mg layer 122 is exposed to oxygen and will become ***partially*** or completely oxidized, depending on the oxidation conditions and the thickness of the Mg layer 122." Ex. 5, ¶63 (emphasis added); Ex. 7 at 35:11–13 (same). Although Parkin teaches that its MgO tunnel barriers "are sufficiently free of defects" that they can act as intended (*e.g.*, Ex. 5, ¶28; Ex. 7 at 20:3–9; *see also, e.g.*, Ex. 5 ¶¶ 19–20; Ex. 7 at 15:20–16:14), Parkin also acknowledges that some defects may be present in view of "the strong temperature dependence of TMR," Ex. 5, ¶71; Ex. 7 at 40:18–20 (same).

Kishi similarly teaches that its tunnel barrier layer can be a number of dielectrics including, specifically, MgO. Ex. 4 ¶ 32; *see also id.* ¶¶ 76 ("The same trend was observed when SiO_2, AlN or MgO were used as the dielectric layer for the tunnel barrier layer."), 83 (same), 90 (same). As explained, Kishi further teaches specific, exemplary embodiments of its MTJs, including Sample 9 that constitutes an MTJ with an MgO barrier layer. *Id.* ¶ 93, TABLE 1.

When Kishi's teachings are applied to Parkin, Parkin's MgO barrier layer would have oxygen vacancy defects as well. Kishi teaches that its MgO barrier layers have oxygen vacancy defects. Kishi teaches that "the present invention requires materials with low potential barriers for tunnel barrier layers…." Ex. 4 ¶ 31. Kishi further teaches that metal oxides (including MgO) "will have varying potential barriers depending on their fabrication conditions." *Id.* ¶ 32. "For example, in the case of Al_2O_3 (AlO_x) films formed by oxidizing an Al film, the potential barrier varies … depending on the degree of oxidation of the Al film." *Id.* Skilled practitioners recognized on the basis of at least this teaching that the potential barrier of other metal oxide films formed by oxidizing a metal layer (such as MgO) also vary depending on the degree of oxidation of the metal film. With further regard to the relationship between the degree of oxidation and barrier height, Kishi teaches that more oxidation is directly correlated to taller/larger barrier heights:

> It is preferable for the oxidation process to not exceed 1 hour for natural oxidation. In addition, in plasma oxidation, oxygen is introduced into the chamber after deposition of the Al film, and RF inverse sputtering is performed, but ***it is preferable for the oxidation time to be no longer than approximately 60 seconds. This is to prevent the barrier height from becoming too high due to prolonged oxidation***, and to prevent oxidation of the Fe layer under the Al film.

Id. ¶ 64 (emphasis added). The fact that further oxidation beyond 60 seconds will increase the barrier height teaches that oxidation is not yet complete. Thus, Kishi teaches skilled practitioners that its desired low potential barriers are achieved by reducing oxidation of the tunnel barrier layer, thus resulting in oxygen vacancy defects.

Moreover, skilled practitioners knew that oxygen vacancy defects are inherent in all metal oxides, including the MgO barrier layers in Parkin and Kishi. For example, Pacchioni taught that "perfect, defect free[] oxides are simply an idealization and do not exist in nature." Ex. 9 at 162. Such defects include oxygen vacancies: "Oxygen vacancies are naturally present in every oxide in the form of S[c]hottky or Frenkel defects and their concentration can be increased or decreased in several ways." *Id.*

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

Parkin in view of Kishi teaches or suggests this limitation. As explained, Parkin discloses that "[t]he thickness of the resulting MgO layer 120' in its MTJs is preferably in the range of 3-50 angstroms, more preferably 3-30 angstroms, still more preferably 3-20 angstroms, and most preferably 4-15 angstroms." Ex. 5 ¶ 55; Ex. 7 at 30:1–3 (same). Kishi teaches a computed value $S/(\phi)^{1/2}$ where S is the physical width (thickness) of the tunnel barrier layer (in Angstroms) and ϕ is the tunnel barrier height (in eV). Ex. 4 ¶ 49. Kishi teaches that the range $10 \leq S/(\phi)^{1/2} \leq 40$ is preferred to inhibit TMR reduction in response to increased temperature or bias voltage. *Id.* ¶ 50. For the upper end of Parkin's most preferable thickness range of 15 Å, for example, one of skill would understand that Kishi's recommended ratio $10 \leq S/(\phi)^{1/2} \leq 40$ would result in barrier heights of 0.14 eV to 2.25 eV ($(15/10)^2 = 2.25$ eV and $(15/40)^2 = 0.14$ eV). The same calculation could be performed for Parkin's remaining recommended range of values yielding a range of

recommended barrier heights. Additionally, for the upper end of Parkin's most preferable thickness range of 15 Å, for example, one of skill also would understand that Kishi's teaching of barrier heights of 0.3 to 1.0 eV would satisfy the preferred range $10 \leq S/(\phi)^{1/2} \leq 40$. *Id.* ¶ 50. Additionally, as discussed above in the Motivation to Combine, one of ordinary skill in the art would understand that Kishi's Sample 9 has a barrier height (ϕ) of 0.26 eV with a barrier width of 20 Å ($(20/39)^2 = 0.26$ eV).

In the first two instances, the barrier heights taught by the combination of Parkin and Kishi (*i.e.*, barrier heights of 0.14 eV to 2.25 eV and 0.3 eV to 1.0 eV), overlap the claimed "range of 0.1 eV to 0.85 eV," thus rendering it prima facie obvious. *In re Woodruff*, 919 F.2d 1575, 1578 (Fed. Cir. 1990) ("These cases have consistently held that in [cases involving overlapping ranges], the applicant must show that the particular range is *critical*, generally by showing that the claimed range achieves unexpected results relative to the prior art range."); MPEP § 2144.05; *see also In re Boesch*, 617 F.2d 272, 276 (C.C.P.A. 1980) ("This accords with the rule that discovery of an optimum value of a result effective variable in a known process is ordinarily within the skill of the art."). In the Sample 9 instance, the 0.26 eV barrier height falls within the claimed range of 0.1 eV to 0.85 eV, disclosing an example within the limitation. Because it would have been obvious to use any of these barrier height values based on Kishi's teachings, Claim 5's barrier height limitation either would have been obvious or is disclosed by Parkin in view of Kishi.

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

Like Claim 5 from which it depends, Claim 6 also would have been obvious over Parkin in view of Kishi.

As explained in Claim 5, the combination of Parkin and Kishi teaches barrier heights of 0.14 eV to 2.25 eV and 0.3 eV to 1.0 eV, which overlap the claimed "range of 0.2 eV to 0.5 eV,"

rendering it prima facie obvious. *In re Woodruff*, 919 F.2d at 1578; MPEP § 2144.05; *see also In re Boesch*, 617 F.2d at 276. Additionally, the combination of Parkin with Kishi's Sample 9 teaches a barrier height of 0.26 eV, which is within the claimed range of 0.2 eV to 0.5 eV.

4. Claim 9

Claim 9 would have been obvious over Parkin in view of Kishi.

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

Supra Claim 1[preamble]; *see also* Claims 1[a]-1[c].

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

Supra Claim 1[a].

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

Supra Claim 1[b].

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

Supra Claims 1[c] and 5.

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

Like Claim 9 from which it depends, Claim 10 also would have been obvious over Parkin in view of Kishi. *Supra* Claim 1[c]. Parkin's MgO layer is at least partially crystalline. Ex. 5 ¶ 74 ("Thermal annealing may also improve the crystallographic texture of the MgO layer 120' and the surrounding layers, so that the structure prior to annealing may not be substantially (100) oriented but after thermal anneal treatments in the temperature range described above the crystallographic texture becomes substantially (100) oriented."); Ex. 7 at 42:22–43:3 (same).

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

Like Claim 10 from which it depends, Claim 11 also would have been obvious over Parkin in view of Kishi. As explained for Claim 9 (referring to Claim 1), Parkin describes annealing to "improve the crystallographic texture of the MgO layer 120' ***and the surrounding layers***," which are the first and second ferromagnetic layers as described above in Claim 1[a] and depicted in Figure 2B. Ex. 5 ¶ 74 (emphasis added); Ex. 7 at 42:22–43:3; *see also* Ex. 5 ¶ 22 ("In preferred implementations, the magnetic material of the overlayer and the magnetic material of the underlayer are both bcc and at least substantially (100) oriented."); Ex. 7 at 17:15–22 (describing both ferromagnetic layers as "substantially (100) oriented"). Thus, the MgO layer and the first and second ferromagnetic material layers are at least partially crystallized.

Additionally, Parkin discloses that the underlying layers 118 and 119 constituting the ferromagnetic layer 115 under the MgO "grow (100) oriented" showing that they are crystalline. Ex. 5 ¶ 57; Ex. 7 at 30:21–31:1 (same); *see also* Ex. 5 ¶ 72 ("It seems very clear that the layer or layers 112 are preferably chosen so that the IrMn layer and ***the ferromagnetic pinned layers grow***

textured in the (100) orientation and that ***the ferromagnetic layer is preferably formed in the bcc crystal structure***." (emphases added)); Ex. 7 at 41:5-8 (same).

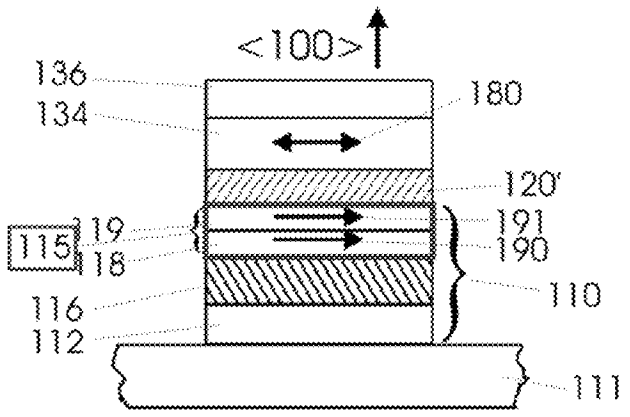


FIG. 2B

Ex. 5 at Fig. 2B (annotated); Ex. 7 at Fig. 2B.

Because only one of the "first ferromagnetic material layer ***and/or*** the second ferromagnetic material layer" need be crystallized, any of these disclosures is sufficient to meet Claim 11.

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

Like Claim 11 from which it depends, Claim 12 also would have been obvious over Parkin in view of Kishi. *Supra* Claims 5, 6.

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

Like Claim 11 from which it depends, Claim 13 also would have been obvious over Parkin in view of Kishi.

Parkin teaches this limitation. Parkin teaches that at least its lower pinned ferromagnetic layer 115 is preferably bcc crystalline. Ex. 5 ¶ 72 ("It seems very clear that the layer or layers 112 are preferably chosen so that the IrMn layer and ***the ferromagnetic pinned layers grow textured***

in the (100) orientation and that ***the ferromagnetic layer is preferably formed in the bcc crystal structure***." (emphases added)); Ex. 7 at 41:5–8 (same); *see also* Ex. 5 at Fig. 2B, ¶ 52 ("[T]he fixed ferromagnetic layer may actually be a bilayer 115 of two different ferromagnetic layers 118 and 119, each having a magnetic moment oriented as indicated by the arrows 190 and 191, respectively."), ¶ 62 ("pinned layer 115"); Ex. 7 at Fig. 2B, 27:23–28:3 (same), 34:8–11 (same).

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

Like Claim 11 from which it depends, Claim 14 also would have been obvious over Parkin in view of Kishi.

Parkin in view of Kishi teaches this limitation. Parkin teaches that its lower pinned ferromagnetic layer 115 (*i.e.*, its first ferromagnetic layer) "can be formed from various Co—Fe alloys" and "can be formed from a single layer of Co—Fe." Ex. 5 ¶ 66; Ex. 7 at 36:16–18 (same); *see also* Ex. 5 ¶¶ 66 ("The pinned ferromagnetic electrode is formed from a single layer of 26 Å $Co_{84}Fe_{16}$."), 72 ("High TMR values … are found for $Co_{1-x}Fe_x$ alloys…."); Ex. 7 at 36:22–23 (same), 41:8–10 (same).

10. Claim 15

Claim 15 is obvious over Parkin in view of Kishi.

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

Supra Claim 1[preamble].

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

Supra Claim 1[a].

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

Supra Claims 1[c], 5, and 6.

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

Supra Claims 1[a] and 1[b].

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

Like Claim 15 from which it depends, Claim 16 also would have been obvious over Parkin in view of Kishi. *Supra* Claim 1[c].

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

Like Claim 16 from which it depends, Claim 17 also would have been obvious over Parkin in view of Kishi. *Supra* Claim 11.

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

Like Claim 17 from which it depends, Claim 18 also would have been obvious over Parkin in view of Kishi. *Supra* Claim 13.

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

Like Claim 17 from which it depends, Claim 19 also would have been obvious over Parkin in view of Kishi. *Supra* Claim 14.

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

Like Claim 15 from which it depends, Claim 20 also would have been obvious over Parkin in view of Kishi.

Parkin in view of Kishi teaches this limitation. Parkin teaches that "[t]he thickness of the resulting MgO layer 120' is preferably in the range of 3-50 angstroms, more preferably 3-30

angstroms, still more preferably 3-20 angstroms, and most preferably 4-15 angstroms." Ex. 5 ¶ 55; Ex. 7 at 30:1-3 (same). These disclosed ranges each fall within the claimed range of "less than 10 nm" (10 nm = 100 Å), thus disclosing the limitation. *In re Haase*, 542 F. App'x 962, 966–67 (Fed. Cir. 2013) (citing *Titanium Metals v. Banner*, 778 F.2d 775, 782 (Fed. Cir. 1985)).

Kishi also teaches this limitation. For example, with respect to Sample 9, Kishi teaches a tunnel barrier thickness (width) of 2 nm. Ex. 4, ¶93, TABLE 1.

X. THE OFFICE SHOULD NOT EXERCISE ITS DISCRETION TO DENY REEXAMINATION

The Office should not deny this request under 35 U.S.C. §§ 315(d) and 325(d). Section 315(d) permits the Director, "during the pendency of an inter partes review," to determine the manner in which another proceeding involving the same patent is to proceed. Section 325(d) further specifies that "the Director may take into account whether, and reject the petition or request because, the same or substantially the same prior art or arguments previously were presented to the Office." As discussed herein, Kishi has not been before the Office during examination or *inter partes* review of U.S. Patent No. 11,968,909. Likewise, the arguments presented here—that Kishi teaches the "0.1 eV to 0.85 eV" and "0.2 eV to 0.5 eV" claimed barrier height ranges; that Kishi alone anticipates Claims 9, 15, and 20; that Parkin combined with Kishi renders all the claims obvious; and the motivation to combine Parkin with Kishi—have not been before the Office.

Nor is the Office precluded from instituting this request by action of 37 C.F.R. § 1.510(a). A request for *ex parte* reexam may be filed "at any time during the period of *enforceability* of a patent." *Id.* The '909 Patent expired March 10, 2025. *See* Ex. 2 at 152–54 (terminal disclaimer in view of U.S. Patent No. 7,884,403); Ex. 1 at 2 (claiming priority to '403 Patent filed as PCT on Mar. 10, 2005); 35 U.S.C. §§ 154(a)(2), 365(c). However, the period of enforceability extends six years beyond expiration. 35 U.S.C. § 286 (six-year limitation on damages for past infringement);

Leinoff v. Louis Milona & Sons, 726 F.2d 734, 741 (Fed. Cir. 1984) (Section 286 "only restricts the extent one can recover prefiling damages. It places no other limitation on the filing of an infringement action…." (emphasis omitted) (overruled in-part on other grounds)). *Ex parte* reexam therefore is permissible here. *In re Gesture Tech.*, 2025 WL 303446, at *3 (Fed. Cir. Jan. 27, 2025) (non-precedential) (rejecting argument that Board lacked jurisdiction over *ex parte* reexam because the patent had expired), *citing Apple v. Gesture Tech.*, 127 F. 4th 364, 368–69 (Fed. Cir. 2025) (recognizing Board's jurisdiction over IPR petition filed after patent expiration but while patentee could still bring "action for past damages").

XI. CONCLUSION

For the reasons set forth in this Request, the Office should order *ex parte* reexamination of the '909 Patent.

Respectfully submitted,

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