

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.

IPR2024-01493
Patent 10,680,167 B2

Before JUSTIN T. ARBES, MONICA S. ULLAGADDI, and
JOHN D. HAMANN, *Administrative Patent Judges*.

HAMANN, *Administrative Patent Judge*.

DECISION
Granting Institution of *Inter Partes* Review
35 U.S.C. § 314

I. INTRODUCTION

Western Digital Technologies, Inc. (“Petitioner”) filed a petition for *inter partes* review of claims 1–15 (“the challenged claims”) of U.S. Patent No. 10,680,167 B2 (Ex. 1013, “the ’167 patent”). Paper 1 (“Pet.”). Godo Kaisha IP Bridge 1 (“Patent Owner”) filed a Preliminary Response. Paper 7 (“Prelim. Resp.”).

Institution of an *inter partes* review is authorized by statute when “the information presented in the petition . . . and any response . . . shows that there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition.” 35 U.S.C. § 314(a) (2024); *see* 37 C.F.R. § 42.108 (2024). Upon consideration of the papers, we conclude that the information presented shows that there is a reasonable likelihood that Petitioner would prevail in establishing the unpatentability of at least one challenged claim of the ’167 patent.

A. *Real Parties-in-Interest*

Petitioner states that “Western Digital Technologies, Inc., and related entity Western Digital Corporation, are the real parties-in-interest.” Pet. 73. Patent Owner states that it is the real party-in-interest. Paper 8, 1.

B. *Related Matters*

The parties identify *Godo Kaisha IP Bridge 1 v. Western Digital Technologies, Inc.*, No. 3:24-cv-06555 (N.D. Cal.); and *Godo Kaisha IP Bridge 1 v. Seagate Technology LLC*, No. 24-cv-3691 (D. Minn.), as matters that may affect, or be affected by, a decision in this proceeding. Pet. 73; Paper 8, 2.

C. *The Challenged Patent*

The ’167 patent “relates to a magnetic tunnel junction device and . . . , particularly to a magnetic tunnel junction device with a high

magnetoresistance.” Ex. 1013, 1:27–30. In particular, the ’167 patent explains that “a MTJ [magnetic tunnel junction] device comprises a tunnelling junction structure in which a tunnel barrier . . . made of an oxide is sandwiched between a first and a second electrode made of a ferromagnetic metal.” *Id.* at 1:42–46. An object of the patent is stated as “to increase the output voltage of a MTJ device.” *Id.* at 2:54–55.

According to the ’167 patent, “the MTJ device structure of [an] embodiment comprises a first Fe (001) layer 1, a second Fe (001) layer 5, and a single-crystalline MgO_x (001) layer 3 or a poly-crystalline MgO_x (0<x<1) layer 3 sandwiched there between, the polycrystalline layer having the (001) crystal plane preferentially oriented therein.” *Id.* at 5:38–44. This structure is shown in Figure 1(B), reproduced below.

FIG. 1 (B)

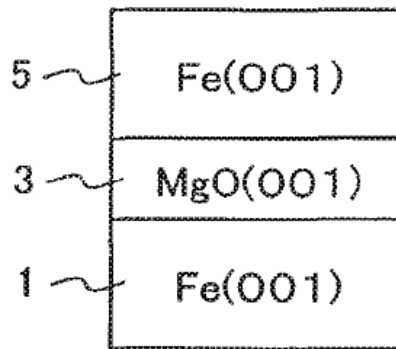


Figure 1(B) “shows the structure of a MTJ device according to” an embodiment of the ’167 patent. *Id.* at 3:65–66. In addition, the ’167 patent discloses a variation— Figure 11 reproduced below—of the structure shown in Figure 1(B). *Id.* at 4:33–34.

FIG. 11

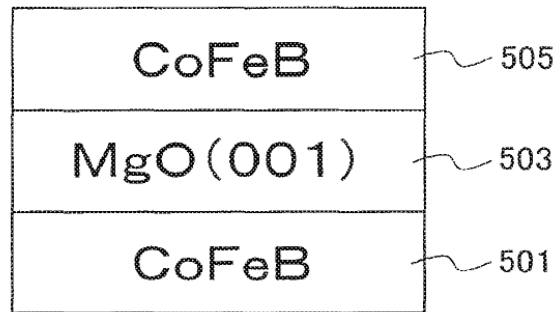


Figure 11 shows “the MTJ device of the variation is characterized in that . . . the electrodes disposed on either side of a single-crystal $\text{MgO}_x(001)$ layer 503 or an oxygen-deficit poly-crystal MgO_x ($0 < x < 1$) in which the (001) crystal plane is preferentially oriented comprises an amorphous ferromagnetic alloy, such as . . . layers 501 and 505,” which consist of Co, Fe, and B. *Id.* at 9:10–16.

D. The Challenged Claims

Petitioner challenges claims 1–15 in this proceeding. Claims 1 and 11 are independent claims. Claim 1 is illustrative of the challenged claims and is reproduced below:

1. A method of manufacturing a magnetic tunnel junction (MTJ) device, comprising:
 - forming a first CoFeB layer that is amorphous;
 - forming a magnesium oxide (MgO) layer over the first CoFeB layer;
 - forming a second CoFeB layer that is amorphous over the MgO layer; and
 - annealing the first and second CoFeB layers and the MgO layer,wherein the first and second CoFeB layers are crystallized by the annealing, and

wherein the MgO layer is poly-crystalline in which a (001) crystal plane is preferentially oriented.

Ex. 1013, 9:55–67.

E. Asserted Grounds of Unpatentability

Petitioner asserts that the challenged claims of the '167 patent are unpatentable based on the following grounds:

Claim(s) Challenged	35 U.S.C. § ¹	Reference(s)/Basis
1–15	103(a)	Bowen, ² Sunai ³
1–15	103(a)	Bowen, Parkin ⁴
7, 8, 14	103(a)	Bowen, Sunai, Soukup ⁵
7, 8, 14	103(a)	Bowen, Parkin, Soukup
1–15	103(a)	Nagahama, ⁶ Sunai
1–15	103(a)	Nagahama, Parkin
7, 8, 14	103(a)	Nagahama, Sunai, Soukup
7, 8, 14	103(a)	Nagahama, Parkin, Soukup

Pet. 17–18, 20–68. Petitioner submits in support of its arguments the Declaration of Jeffrey Bokor, Ph.D. (Ex. 1024).

¹ The Leahy-Smith America Invents Act (“AIA”) included revisions to 35 U.S.C. § 103 that became effective on March 16, 2013. Because the '167 patent issued from an application having an effective filing date before March 16, 2013, we apply the pre-AIA version of the statutory basis for unpatentability.

² M. Bowen et al., *Large magnetoresistance in Fe/MgO/FeCo(001) epitaxial tunnel junctions on GaAs(001)*, Appl. Phys. Lett., vol. 79, no. 11, 1655–57 (Sept. 10, 2001) (Ex. 1026, “Bowen”).

³ JP 2002/204004 A, published July 19, 2002 (Ex. 1030, “Sunai”) (as translated).

⁴ US 7,270,896 B2, issued Sept. 18, 2007 (Ex. 1062, “Parkin”).

⁵ R. J. Soukup, *Voltage-current characteristics for electrical conduction through thin MgO films*, J. Appl. Phys., Vol. 41, No. 8, 3229–3236 (1970) (Ex. 1028, “Soukup”).

⁶ EP 1 391 942 A1, published Feb. 25, 2004 (Ex. 1027, “Nagahama”).

II. LEVEL OF ORDINARY SKILL IN THE ART

To determine whether an invention would have been obvious at the time it was made, we consider the level of ordinary skill in the pertinent art at the time of the invention. *Graham v. John Deere Co.*, 383 U.S. 1, 17 (1966). In assessing the level of ordinary skill in the art, various factors may be considered, including the “type of problems encountered in the art; prior art solutions to those problems; rapidity with which innovations are made; sophistication of the technology; and educational level of active workers in the field.” *In re GPAC, Inc.*, 57 F.3d 1573, 1579 (Fed. Cir. 1995) (citing *Custom Accessories, Inc. v. Jeffrey-Allan Indus., Inc.*, 807 F.2d 955, 962–63 (Fed. Cir. 1986)). “[O]ne or more factors may predominate.” *Id.*

Petitioner argues that one of ordinary skill in the art would have had “a Ph.D. in electrical engineering, physics, materials science, or a related field, and at least one year of experience in the research, design, and/or development of magnetic/spintronic devices, or the equivalent,” or “a Master’s degree in electrical engineering, physics, materials science, or a related field, and four years of experience in the research, design, and/or development of magnetic/spintronic devices, or the equivalent.” Pet. 20 (citing Ex. 1024 ¶ 25). Petitioner adds that “[l]ess work experience may be compensated by a higher level of relevant education, and vice versa.” *Id.*

Patent Owner does not identify a level of skill in the art that one would have had at the time of the invention of the ’167 patent or identify any shortcoming in Petitioner’s formulation. Prelim. Resp. 18.

For purposes of this Decision, we adopt Petitioner’s definition of the level of skill for one of ordinary skill in the art. Pet. 20. We view this definition for the level of ordinary skill to be consistent with the ’167 patent and the asserted prior art, and we apply it in our analysis below.

III. CLAIM CONSTRUCTION

Because the Petition was filed after November 13, 2018, we apply the same claim construction standard that would be used in a civil action under 35 U.S.C. § 282(b), following the standard articulated in *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (en banc). 37 C.F.R. § 42.100(b); 83 Fed. Reg. 51,340, 51,340–41, 51,343 (Oct. 11, 2018). In applying such standard, claim terms generally are given their ordinary and customary meaning, as would be understood by a person of ordinary skill in the art, at the time of the invention and in the context of the entire patent disclosure. *Phillips*, 415 F.3d at 1312–13. “In determining the meaning of the disputed claim limitation, we look principally to the intrinsic evidence of record, examining the claim language itself, the written description, and the prosecution history, if in evidence.” *DePuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.*, 469 F.3d 1005, 1014 (Fed. Cir. 2006) (citing *Phillips*, 415 F.3d at 1312–17).

Here, neither party sets forth any term for claim construction. Pet. 17; *see generally* Prelim. Resp. Thus, for purposes of this Decision, we afford the claim terms their plain and ordinary meaning. *See, e.g., Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (quoting *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999) (“[W]e need only construe terms ‘that are in controversy, and only to the extent necessary to resolve the controversy.’”)).

IV. PRINCIPLES OF LAW

A claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the claimed subject matter and the prior art are such that the subject matter, as a whole, would have been obvious at the time of the invention to a person having ordinary skill in the art. *KSR Int’l Co. v. Teleflex, Inc.*, 550

U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations, including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) objective evidence of non-obviousness, if present.⁷ *See Graham*, 383 U.S. at 17–18. When evaluating a claim for obviousness, we also must “determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue.” *KSR*, 550 U.S. at 418 (citing *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006)).

V. ALLEGED OBVIOUSNESS OVER BOWEN AND SUNAI

Petitioner argues that the combination of Bowen and Sunai renders claims 1–15 obvious. Pet. 20–48. Patent Owner disputes this. Prelim. Resp. 18–27, 29–32. For the reasons that follow, we determine that Petitioner establishes a reasonable likelihood that it would prevail in showing that the combination of Bowen and Sunai renders at least one challenged claim obvious.

A. *Summary of Bowen*

Bowen describes that “magnetoresistance of magnetic tunnel junctions (MTJs) is of uncontested interest for important applications with, in particular, promising perspectives for the fabrication of nonvolatile memories (Magnetic RAM)” (MRAM). Ex. 1026, 1655 (footnote omitted). Bowen “present[s] tunneling experiments on Fe(001)/MgO(20 Å)/FeCo(001) single-crystal epitaxial junctions of high quality grown by sputtering and laser ablation.” *Id.* at Abstract.

⁷ Patent Owner does not present arguments or evidence of such objective evidence of non-obviousness. *See generally* Prelim. Resp.

Bowen discloses that “numerical calculations of spin-dependent tunneling and TMR [(tunneling magnetoresistance)] have been developed for single crystal MTJs such as . . . Fe/MgO(100),” and that they “emphasize that a correct depiction of the spin-dependent tunneling properties of epitaxial MTJs must transcend the simple potential barrier image and take into account the interplay of electronic structure between metal and insulator.” *Id.* at 1655 (footnotes omitted). Bowen describes that “much work has been expended to characterize the growth and electrical behavior of ultrathin MgO layers,” and presents “experimental results showing large TMR values in Fe(001)/MgO(001)/FeCo(001) epitaxial tunnel junctions.” *Id.*

B. Summary of Sunai

Sunai is directed to “a magnetoresistance effect element, magnetic memory, magnetic head, and magnetic reproducing device that can maintain a sufficiently high magnetoresistance ratio and prevent an increase in the reversal magnetic field even when the size is reduced.” Ex. 1030, Abstract. Sunai explains that prior art “MRAM has a problem in that when the size of the memory cell is reduced to increase the capacity, the magnetic field required to reverse the magnetization direction of the free layer, the so-called reversal magnetic field, becomes larger, and a larger write current is required.” *Id.* ¶¶ 4–5, 9.

In order to solve the above problem, [Sunai] provides a magnetoresistance effect element comprising a first ferromagnetic layer that maintains the direction of magnetization when a predetermined external magnetic field is not applied, a second ferromagnetic layer that can change the direction of magnetization when the external magnetic field is not applied, and a first tunnel barrier layer interposed between the first ferromagnetic layer and the second ferromagnetic layer, wherein

the first ferromagnetic layer, the first tunnel barrier layer, and the second ferromagnetic layer form a ferromagnetic tunnel junction, and wherein the composition of the ferromagnetic material contained in the second ferromagnetic layer is expressed by the general formula $(\text{CoFe})_{100-x}\text{Y}_x$ or the general formula $(\text{CoFeNi})_{100-x}\text{Y}_x$, where Y is at least one element selected from the group consisting of B, Si, Zr, P, Mo, Al, and Nb.

Id. ¶ 11.

Sunai discloses that “[i]n a normal film formation method at room temperature, the lower limit of the film thickness at which a Co_9Fe film that does not contain B can be formed as a continuous film is about 1.5 nm.” *Id.*

¶ 27. But, “when B is added to Co_9Fe , a continuous film can be formed up to a film thickness of about 0.5 nm.” *Id.* ¶ 28. Sunai explains that the

“reason that an extremely thin continuous film can be formed when the element Y is added is that the addition of the element Y suppresses the diffusion or movement of atoms that reach the film formation surface during the film formation process, thereby suppressing crystallization.” *Id.* ¶ 30.

Conversely, Sunai states that in the prior art, when Y is not added, “when the film thickness is thinned, island structures are formed in which each island has a diameter of about several nanometers, and although each island is a ferromagnetic material, it exhibits superparamagnetism, in which the magnetization direction fluctuates, resulting in a significantly low magnetoresistance change rate.” *Id.*

C. Challenged Claim 1

1. Manufacturing a MTJ (Preamble)

Claim 1’s preamble recites “[a] method of manufacturing a magnetic tunnel junction (MTJ) device.” Ex. 1013, 9:55–56. At this stage, we agree with Petitioner and find that Bowen teaches a manufacturing process for fabricating a MTJ device. Pet. 21–22.

In particular, we agree with Petitioner and find that Bowen teaches manufacturing a MTJ device in which “FeCo/MgO/Fe epitaxial structures were grown on GaAs(001) in a combined sputtering/laser ablation system.” Ex. 1026, 1655. More specifically, Bowen teaches the following:

Fe₅₀Co₅₀ and Fe layers were deposited from individual Fe and Co targets by triode sputtering with an Ar pressure of 4×10^{-4} mbar and with deposition rates in the range of 0.1–0.3 Å/s. Optimal deposition temperatures were 400 °C for the MgO, [room temperature] for FeCo top electrode, and [room temperature] plus annealing at 400 °C for the Fe bottom electrode. This low-temperature deposition and subsequent annealing process leads to an optimal Fe electrode in terms of crystallinity, continuity, and interface sharpness.

Id.; Ex. 1024 ¶ 114.

In sum, we find that Petitioner shows, for purposes of this institution decision, that Bowen teaches claim 1’s preamble. In light of our finding, we need not, and thus do not, reach whether claim 1’s preamble is limiting.

2. Forming First CoFeB Layer

Claim 1 further recites “forming a first CoFeB layer that is amorphous.” Ex. 1013, 9:57. At this stage, we agree with Petitioner and find that the combination of Bowen and Sunai teaches this limitation. Pet. 22–26.

In particular, we agree with Petitioner that Bowen teaches forming a first (i.e., lower or closest to the substrate) Fe ferromagnetic layer. Ex. 1026, 1655–56, Abstract, Fig. 1; Pet. 23; *see also* Ex. 1008,⁸ 268 (Examiner finding that “[i]t is inherent the first ferromagnetic material layer would be deposited on a substrate”) (emphasis omitted).

⁸ File History for related U.S. Patent No. 9,123,463 B2.

At this stage, we also agree with Petitioner that “[o]ne of skill would have found it obvious to replace Bowen’s Fe layer with an amorphous ferromagnetic CoFeB layer as taught by Sunai.” Pet. 23. First, Sunai teaches forming an amorphous CoFeB ferromagnetic layer for its magnetoresistance effect element. Ex. 1030 ¶¶ 24–30. More specifically, Sunai teaches adding B to a CoFe ferromagnetic material for this layer so that crystallization is inhibited when forming a thin continuous film; without adding B, island structures would be formed as the film thickness is thinned. *Id.* ¶¶ 25, 28, 30; Ex. 1024 ¶ 130 (citing Ex. 1030 ¶¶ 24–25, 30) (“As Sunai recognized, it was known that adding boron resulted in an amorphous CoFeB layer.”); *see also* Ex. 1062, 17:40–53 (discussing CoFeB formed as an “amorphous” layer).

Second, on this record we agree that one of ordinary skill in the art would have been motivated to substitute Sunai’s CoFeB layer for Bowen’s Fe layer to increase the tunnel magnetoresistance ratio (“TMR”) of Bowen’s MTJ. Pet. 24; Ex. 1055,⁹ 2269–70 (“The benefit of using CoFeB” includes “a higher TMR value.”), 2270 (“[I]t is natural to replace both the free and pinned layers to CoFeB to further increase the TMR value.”); Ex. 1056¹⁰ ¶ 39 (“[A]n amorphous layer comprised of a CoFeB alloy . . . exhibits a larger TMR ratio.”), ¶¶ 67–68 (“In the construction[,] . . . ferromagnetic layers 5, 7 are made of an FeCoB^[11] . . . material containing B so as to have

⁹ Dexin Wang et al., *70% TMR at room temperature for SDT sandwich junctions with CoFeB as free and reference layers*, 40 IEEE Trans. Magn. 2269–71 (July 2004).

¹⁰ US 2004/0136232 A1, published July 15, 2004.

¹¹ We are persuaded by Dr. Bokor’s testimony that “a skilled artisan [would have] understood that CoFeB and FeCoB refer to the same alloy.” Ex. 1024 ¶ 121.

an amorphous structure,” and thus, can realize “improvement of the TMR ratio.”); Ex. 1024 ¶ 129. Moreover, as Petitioner explains, “[r]esearchers were . . . interested in optimizing MTJs to improve MRAM performance,” and “[h]igher TMRs long promised improved performance for MRAM.” Pet. 6 (citing Ex. 1026, 1655; Ex. 1045,¹² 1; Ex. 1049,¹³ 186; Ex. 1024 ¶¶ 31, 36–44) (emphasis omitted).

In addition, on this record we agree with Petitioner that Bowen and Sunai teach forming an MgO barrier layer and ferromagnetic alloy electrodes. Pet. 25–26 (citing Ex. 1026, 1655, Abstract; Ex. 1030 ¶¶ 24, 35; Ex. 1024 ¶ 126). And we also agree that one of ordinary skill in the art would have had a reasonable expectation of success in modifying Bowen as forming electrodes with CoFeB alloys was known. *Id.* at 26.

In sum, we find that Petitioner shows, for purposes of this institution decision, that the combination of Bowen and Sunai teaches this limitation.

3. *Forming MgO Layer*

Claim 1 further recites “forming a magnesium oxide (MgO) layer over the first CoFeB layer.” Ex. 1013, 9:58–59. At this stage, we agree with Petitioner and find that the combination of Bowen and Sunai teaches this limitation. Pet. 28–29.

In particular, we agree with Petitioner and find that Bowen teaches forming an MgO layer epitaxially over a lower Fe layer. Pet. 28–29; Ex. 1026, 1655–56, Fig. 1, Abstract. And as we discuss above, we agree

¹² M. Klaua et al., *Growth, structure, electronic, and magnetic properties of MgO/Fe(001) bilayers and Fe/MgO/Fe(001) trilayers*, 64 Phys. Rev. B. vol. 64, 134411 (2001) (“Klaua”).

¹³ Chang-Shuk Kim et al., *MRAM Technology for High Density Memory Application*, 2 J. Semicond. Tech. Sci. 185–96 (Sept. 2002).

that one of ordinary skill would have found it obvious to substitute Sunai's CoFeB layer for Bowen's Fe layer. *See supra* Section V.C.2. And thus, the combination teaches forming a MgO layer over the CoFeB layer. In addition, we also agree with Petitioner that forming an oxide layer over a ferromagnetic layer in an MTJ was known. Pet. 29 (citing Ex. 1013, 1:42–46 (describing Figure 8A), Fig. 8A (labeled prior art)).

At this stage, we find unavailing Patent Owner's argument that "the Petition does not address whether the claimed MgO layer . . . could be grown on the substituted CoFeB layer of Sunai." Prelim. Resp. 31. Rather, Petitioner explains that it was known to add B "to form a CoFeB electrode [which] resulted in an initially 'amorphous structure,'" and "[a]s a result, a 'CoFeB/MgO/CoFeB MTJ can theoretically be grown on all kinds of underlayers.'" Pet. 10–11 (citing Ex. 1055, Abstract; Ex. 1030 ¶¶ 24–25, 30; Ex. 1057,¹⁴ 47; Ex. 1024 ¶ 60). Thus, the evidence supports Petitioner's contention that a MgO layer could be grown on a CoFeB layer. *E.g.*, Ex. 1057, 47. Moreover, as we discuss above, Dr. Bokor testifies that Sunai teaches forming an MgO barrier layer and ferromagnetic alloy electrodes. Ex. 1024 ¶ 126 (citing Ex. 1030 ¶¶ 24, 35); *see also* Ex. 1030 ¶¶ 24 (teaching CoFeB electrodes), 35 ("The materials of the tunnel barrier layers . . . can include, for example, Al, Si, Mg, rare earth elements, or oxides . . . of alloys containing these elements.").

In sum, we find that Petitioner shows, for purposes of this institution decision, that the combination of Bowen and Sunai teaches this limitation.

¹⁴ Dieny et al., *Introduction to Magnetic Random-Access Memory* (IEEE Press 2017) (excerpts).

4. *Forming Second CoFeB Layer*

Claim 1 further recites “forming a second CoFeB layer that is amorphous over the MgO layer.” Ex. 1013, 9:60–61. At this stage, we agree with Petitioner and find that the combination of Bowen and Sunai teaches this limitation. Pet. 28–29.

In particular, we agree with Petitioner on this record and find that Bowen teaches forming a second FeCo ferromagnetic layer (i.e., a top electrode) over its MgO barrier layer. *Id.* at 29; Ex. 1026, 1655–56, Abstract. In addition, we agree with Petitioner and find that one of ordinary skill in the art would have been motivated to replace Bowen’s top FeCo electrode layer with an amorphous CoFeB layer, as taught by Sunai, for the reasons we discuss above. *See supra* Section V.C.2 (finding the combination of Bowen and Sunai teaches forming a first amorphous CoFeB layer).

In sum, we find that Petitioner shows, for purposes of this institution decision, that the combination of Bowen and Sunai teaches this limitation.

5. *Annealing the Layers*

Claim 1 further recites “annealing the first and second CoFeB layers and the MgO layer, wherein the first and second CoFeB layers are crystallized by the annealing.” Ex. 1013, 9:62–65. At this stage, we agree with Petitioner and find that the combination of Bowen and Sunai teaches this limitation to one of ordinary skill in the art. Pet. 30–32.

In particular, we agree with Petitioner and find that Bowen teaches annealing its Fe bottom layer (closest to the substrate) and MgO barrier layer. Pet. 30; Ex. 1026, 1655 (teaching that (i) “[o]ptimal deposition temperatures were 400 °C for the MgO, [room temperature] for FeCo top electrode, and [room temperature] plus annealing at 400 °C for the Fe

bottom electrode”; and (ii) “the MgO barrier is grown at 400 °C in order to obtain good crystallinity”). More broadly, we agree with Petitioner that “[a]nnealing ferromagnetic electrodes and MgO barrier layers was known.” Pet. 30; Ex. 1026, 1655; Ex. 1045, 1; Ex. 1062, 7:32–50, 7:53–59, 8:50–60; Ex. 1024 ¶¶ 151–153.

In addition, we also agree with Petitioner and find that “[a]nnealing CoFeB electrodes to crystallize them was also known.” Pet. 30–31; Ex. 1060,¹⁵ 311 (“[T]he CoFeB layer is confirmed to be amorphous in the as-deposited state and begin[s] to crystallize after annealing at 250°C.”); Ex. 1061,¹⁶ 2272–73 (“After deposition, the structures were annealed 10 min at 280 °C,” and “X-ray measurements . . . confirmed that the CoFeB films are not amorphous”); Ex. 1062, 7:53–59, 8:50–67; Ex. 1024 ¶¶ 154–155, 162–166.

And at this stage, we agree with Petitioner and find that it was known that a MTJ’s TMR was enhanced by annealing. Pet. 31; Ex. 1026, 1655–57; Ex. 1060, 311 (teaching that the TMR was enhanced by the annealing of the CoFeB layer); Ex. 1062, 7:32–50, 7:53–59, 8:50–67 (teaching that a tunnel junction having a MgO barrier layer and amorphous ferromagnetic layers “may be advantageously annealed to improve its TMR”); Ex. 1024 ¶¶ 155, 164–166. Thus, we agree with Petitioner and find that one of ordinary skill in the art would have been motivated to anneal the CoFeB layers and MgO barrier layer of Petitioner’s proposed combination of Bowen and Sunai to

¹⁵ M. Jimbo et al., *Thermal stability of spin valves using amorphous CoFeB*, 165 J. Magnetism & Magnetic Materials 308–11 (1997) (“Jimbo”).

¹⁶ Susana Cardoso et al., *Ferromagnetic Coupling Field Reduction in CoFeB Tunnel Junctions Deposited by Ion Beam*, 40 IEEE Trans. Magn. 2272–74 (July 2004) (“Cardoso”).

increase TMR. Pet. 31; Ex. 1024 ¶¶ 155, 162, 164–166. As we discuss above, obtaining higher TMRs to improve performance of MRAM was desired. *See supra* Section V.C.2.

At this stage, we find unavailing Patent Owner’s arguments that Sunai teaches that its CoFeB ferromagnetic layer is amorphous, and thus teaches away from CoFeB layers with crystalline structure. Prelim. Resp. 3, 20–24. Rather, Sunai teaches adding B to CoFe so that crystallization is inhibited when *forming* an amorphous continuous CoFeB layer; without adding B, island structures would be formed as the film thickness is thinned, causing lower TMR. Ex. 1030 ¶¶ 25, 28, 30. Patent Owner’s arguments incorrectly conflate the subsequent annealing step—which crystallizes the first and second CoFeB layers and occurs after these layers are formed—with the earlier formation steps of the CoFeB amorphous layers.

We also find unavailing Patent Owner’s arguments that Jimbo’s teachings are inapplicable to Petitioner’s combination of Bowen and Sunai. Prelim. Resp. 24–25. First, we find unavailing Patent Owner’s argument that Jimbo teaches an amorphous CoFeB layer, which is not crystalline. *Id.* at 24. As above, Patent Owner incorrectly conflates the formation of a CoFeB layer with its subsequent annealing. Second, we find unavailing Patent Owner’s argument that Jimbo’s “XRD data shows peaks for CoFe (*i.e.*, without boron),” and thus, Jimbo’s “disclosure is consistent with the teaching in Sunai . . . that boron inhibits crystallization.” *Id.* at 24–25 (citing Ex. 1060, 308, Figs. 1, 3; Ex. 1030 ¶¶ 25, 29–30). This argument does not address that the cited figures’ captions state that they illustrate XRD data for patterns having a CoFeB layer. Ex. 1060, 309 (Figures 1 and 3). Nor does Patent Owner sufficiently explain how the XRD data peaks are purportedly consistent with Sunai’s teachings concerning B inhibiting crystallization, but

instead Patent Owner relies on unsupported attorney argument. Prelim. Resp. 24–25; *In re Geisler*, 116 F.3d 1465, 1471 (Fed. Cir. 1997) (explaining that attorney arguments and conclusory statements that are unsupported by factual evidence are entitled to little probative value). Notably, Patent Owner’s argument also does not address Jimbo’s explicit teaching that “the CoFeB layer is confirmed to be amorphous in the as-deposited state and begin[s] to crystallize after annealing at 250°C,” and that “[t]he [T]MR effect itself is not only stable up to above 300°C but also enhanced by the annealing.” Ex. 1060, 311.

We also find unavailing Patent Owner’s arguments that Cardoso’s teachings are inapplicable to Petitioner’s combination of Bowen and Sunai. Prelim. Resp. 25–26. Rather, as we discuss above, we find that Cardoso supports Petitioner’s argument that annealing CoFeB electrodes to crystallize them was known. In particular, we find unavailing Patent Owner’s argument that Cardoso stated that it was “‘unexpected’ for CoFeB to be crystallized because ‘other groups obtained amorphous films when . . . Boron was incorporated.’” *Id.* at 25 (citing Ex. 1061, 2273) (alteration in original). Whether it was unexpected to Cardoso is inapposite because Cardoso’s teachings to the contrary became part of the knowledge of one of ordinary skill in the art. We also find unavailing Patent Owner’s argument that Cardoso’s CoFeB layer “is surrounded by different layers with different material properties than would have been the case in Petitioner’s Bowen-Sunai” combination, and “[t]hus, the environment in which any anneal would be performed . . . would be different.” *Id.* at 26 (citing Ex. 1061, 2272–73). Patent Owner provides no principled basis to suggest that this is relevant. Nor does Patent Owner provide any principled basis to suggest

that it is relevant that Cardoso's CoFeB layer purportedly is made in a different way. *Id.*

We also find unavailing Patent Owner's argument that Klaau's teachings are inapplicable to Petitioner's combination of Bowen and Sunai. *Id.* at 27. More specifically, at this stage, we disagree with Patent Owner that Klaau is "irrelevant because . . . it relates to crystallization of MgO and Fe structures, not CoFeB." *Id.* Rather, at this stage, we find that Klaau's teachings would have provided some suggestion of annealing other ferromagnetic materials such as CoFeB. *See* Ex. 1045, 1; *KSR*, 550 at 421 ("When there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions, a person of ordinary skill has good reason to pursue the known options within his or her technical grasp.").

We also find unavailing Patent Owner's argument that the Petition does not address claim 1 "as a whole" because "[t]he Petition never addresses the impact of replacing Bowen's Fe ferromagnetic layer with Sunai's . . . CoFeB ferromagnetic layer on the remainder of Bowen's structure and whether it would meet the claim[] as [a] whole." Prelim. Resp. 30 (citing Pet. 30–35). Rather, based on the current record, we are persuaded that Petitioner identifies specific teachings in Bowen and Sunai that teach each and every limitation of claim 1 to one of ordinary skill in the art, and articulates specific rationale to support that one of ordinary skill in the art would have combined Bowen and Sunai's teachings in the manner Petitioner proposes. *See supra* Section V.C.

We also find unavailing Patent Owner's argument that Petitioner does not address that annealing a CoFeB layer, which starts in an amorphous form, "would result in only a thin crystalline layer with the bulk of that

CoFeB remaining amorphous after the anneal.” Prelim. Resp. 31 (citing Ex. 1062, 18:59–62). Notably, claim 2 recites “[t]he method of claim 1, wherein after the annealing, the first and second CoFeB layers are entirely crystallized.” Ex. 1013, 10:1–3. Thus, at this stage, we view claim 1 as not requiring that the entirety of the first and second CoFeB layers be crystallized. *Phillips*, 415 F.3d at 1315 (“[T]he presence of a dependent claim that adds a particular limitation gives rise to a presumption that the limitation in question is not present in the independent claim.”); *Liebel-Flarsheim Co. v. Medrad, Inc.*, 358 F.3d 898, 910 (Fed. Cir. 2004) (“[W]here the limitation that is sought to be ‘read into’ an independent claim already appears in a dependent claim, the doctrine of claim differentiation is at its strongest.”). Regardless, Patent Owner cites Parkin in support of its argument, but does not address the thickness of the referenced storage layer as compared to Bowen’s Fe layer or the proffered CoFeB layer. Thus, how much weight this teaching from Parkin should be afforded is unclear.

In sum, we find that Petitioner shows, for purposes of this institution decision, that the combination of Bowen and Sunai teaches this limitation.

6. MgO Layer is Poly-Crystalline Preferentially Oriented

Claim 1 further recites “wherein the MgO layer is poly-crystalline in which a (001) crystal plane is preferentially oriented.” Ex. 1013, 9:66–67. At this stage, we agree with Petitioner and find that the combination of Bowen and Sunai teaches this limitation to one of ordinary skill. Pet. 33–35.

In particular, we agree with Petitioner and find that Bowen teaches a single-crystal MgO (001) barrier layer. Pet. 33; Ex. 1026, Abstract, 1655; Ex. 1024 ¶ 172. At this stage, we also agree that one of ordinary skill in the art would have found it “obvious to use a polycrystalline MgO with the (001) crystal plane preferentially oriented in place of Bowen’s single-crystal

MgO barrier.” Pet. 33. In particular, Bowen acknowledged that using “polycrystalline MgO” to obtain Bowen’s barrier height of 0.9 eV was known. Ex. 1026, 1656 (citing Ex. 1038¹⁷); *see also* Ex. 1047,¹⁸ 509, 511 nn.5–7 (teaching that “[s]tudies using polycrystalline MgO indicated a low tunneling barrier of ≈ 0.9 eV”). At this stage, we also agree with Petitioner and find that one of ordinary skill in the art would have understood that substituting polycrystalline MgO for single-crystal MgO would have improved flexibility in substrate selection. Pet. 34; Ex. 1062, 9:58–10:2 (“Notwithstanding the polycrystalline nature of the film structures described herein, which are in any case preferable for ease of manufacturing, the method of forming the MgO (or Mg-ZnO) tunnel barrier described herein can also be applied to the growth of epitaxial single crystalline film structures.”); Ex. 1024 ¶ 175.

In sum, we find that Petitioner shows, for purposes of this institution decision, that the combination of Bowen and Sunai teaches this limitation.

7. Summary

In summary, based on the current record, and for purposes of this institution decision, we determine that Petitioner shows a reasonable likelihood that it would prevail in showing that claim 1 would have been obvious to one of ordinary skill in the art in view of Bowen and Sunai.

¹⁷ Jagadeesh S. Moodera & Lisa R. Kinder, *Ferromagnetic–insulator–ferromagnetic tunneling: Spin-dependent tunneling and large magnetoresistance in trilayer junctions (invited)*, 79 J. Appl. Phys. 4724–29 (Apr. 15, 1996).

¹⁸ W. Wulfhchel et al., *Single-crystal magnetotunnel junctions*, 78 Appl. Phys. Letters 509–11 (Jan. 22, 2001).

VI. OTHER CLAIMS AND REMAINING GROUNDS

Because Petitioner demonstrates a reasonable likelihood of success in proving that at least one claim of the '167 patent is unpatentable in view of Bowen and Sunai, we institute on all grounds and all claims raised in the Petition. *See* 37 C.F.R. § 42.108(a). Therefore, at this stage of the proceeding, it is not necessary for us to provide an assessment of every challenge raised by Petitioner, especially when Patent Owner does not address the merits of those challenges.

Here, Patent Owner does not separately address Petitioner's arguments that the combination of Bowen and Sunai teaches claims 2–15, and instead Patent Owner relies on its arguments for claim 1, which we address above. Prelim. Resp. 33. As to the Bowen and Parkin ground, Patent Owner's arguments are substantively the same as its arguments for the Bowen and Sunai ground, and thus, our reasoning there also applies to these arguments. Patent Owner does not address separately the Bowen, Sunai, and Soukup ground, nor the Bowen, Parkin, and Soukup ground. *See generally id.*

In addition, Patent Owner's arguments for the Nagahama and Sunai, and Nagahama and Parkin grounds, are substantively the same as its arguments relating to Bowen and Sunai and claim 1. *See id.* at 33–40. Patent Owner does not address separately the Nagahama, Sunai, and Soukup ground, nor the Nagahama, Parkin, and Soukup ground. *See generally id.*

Accordingly, these remaining challenges, in our view, are best left for trial after full development of the record.

VII. CONCLUSION

For the foregoing reasons, we determine that Petitioner has shown a reasonable likelihood that it would prevail in proving the unpatentability of

at least one of the challenged claims of the '167 patent. We thus institute an *inter partes* review of all of the challenged claims of the '167 patent on all grounds asserted in the Petition.

Any findings or conclusions in this Decision are made only for the purposes of institution and are not dispositive of any issue. We have not made a final determination with respect to the patentability of any challenged claim. Our final determination will be based on the record as fully developed during trial, including any evidence or argument timely presented by the parties under our Rules.

VIII. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that, pursuant to 35 U.S.C. § 314(a), an *inter partes* review of the '167 patent is instituted on all of the challenged claims and all grounds asserted in the Petition; and

FURTHER ORDERED that pursuant to 35 U.S.C. § 314(c) and 37 C.F.R. § 42.4, notice is hereby given of the institution of a trial; the trial commences on the entry date of this Decision.

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