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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

WESTERN DIGITAL TECHNOLOGIES, INC.,
Petitioner,

v.

GODO KAISHA IP BRIDGE 1,
Patent Owner.

Case No. IPR2024-01494
U.S. Patent No. 11,968,909

PETITIONER'S REPLY TO PATENT OWNER RESPONSE

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1027	European Patent Application No. EP1391942A1 to Nagahama et al. (“Nagahama”)
1028	Soukup et al., <i>Voltage-Current Characteristics for Electrical Conduction Through Thin MgO Films</i> , 41 J. Appl. Phys. 3229-3236 (1970) (“Soukup”)
1029	Japanese Patent Application Publication No. JP2002204004A to Sunai et al. (“Sunai”)
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1032	Trasatti, <i>Electronegativity, Work Function, and Heat of Adsorption of Hydrogen on Metals</i> , 67 J. Chem. Soc. 229-236 (1972)
1033	Jullière, <i>Tunneling between ferromagnetic films</i> , 54A Phys. Letters 225-226 (1975)
1034	Miyazaki et al., <i>Giant magnetic tunneling effect in Fe / Al₂O₃ / Fe junction</i> , 139 J. Magnetism & Magnetic Materials L231-L234 (1995)
1035	Moodera et al., <i>Large Magnetoresistance at Room Temperature in Ferromagnetic Thin Film Tunnel Junctions</i> , 74 Phys. Rev. Lett. 3273–3276 (1995)
1036	Wulff et al., <i>Characterization of MgO Layers on Different Alumina and Glass Substrates by Grazing Incidence Diffractometry and Grazing Incidence X-ray Reflectometry</i> , 23 Surface & Interface Analysis 148-154 (1995)

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1037	Castanier et al., <i>Oxygen vacancies on MgO(100)</i> , 364 Surf. Sci. 1-16 (1996)
1038	Moodera et al., <i>Ferromagnetic–insulator–ferromagnetic tunneling: Spin-dependent tunneling and large magnetoresistance in trilayer junctions (invited)</i> , 79 J. Appl. Phys. 4724-4729 (1996)
1039	Tehrani et al., <i>Progress and Outlook for MRAM Technology</i> , 35 IEEE Trans. Magn. 2814-2819 (1999)
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1043	Heinrich et al., <i>Single Crystal Tunnel Junctions</i> , IEEE (2000)
1044	Butler et al., <i>Spin-dependent tunneling conductance of Fe MgO Fe sandwiches</i> , 63 Phys. Rev. B 054416 (2001)
1045	Klaaua et al., <i>Growth, structure, electronic, and magnetic properties of MgO/Fe(001) bilayers and Fe/MgO/Fe(001) trilayers</i> , 64 Phys. Rev. B. 134411 (2001)
1046	Mathon et al., <i>Theory of tunneling magnetoresistance of an epitaxial Fe/MgO/Fe(001) junction</i> , 63 Phys. Rev. 220403 (2001)
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1048	Bogicevic et al., <i>Effect of oxide vacancies on metal island nucleation</i> , 515 Surf. Sci. L481-486 (2002)
1049	Kim et al., <i>MRAM Technology for High Density Memory Application</i> , 2 J. Semicond. Tech. Sci. 185-196 (2002)
1050	Yuasa et al., <i>A large quantum-well oscillation of the TMR effect</i> , 35 J. Phys. D. 2427-2431 (2002)
1051	Meyerheim, et al., <i>Geometrical and Compositional Structure at Metal-Oxide Interfaces: MgO on Fe(001)</i> , 87 Phys. Rev. Letters 076102 (2001)

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1052	Faure-Vincent et al., <i>High tunnel magnetoresistance in epitaxial Fe/MgO/Fe tunnel junctions</i> , 82 App. Phys. Letters 4507-4509 (2003)
1053	Mitani et al., <i>Fe/MgO/FeCo(100) epitaxial magnetic tunnel junctions prepared by using in situ plasma oxidation</i> , 93 J. Appl. Phys. 8041-8043 (2003)
1054	Goniakowski et al., <i>Electronic States and Schottky Barrier Height at Metal/MgO(100) Interfaces</i> , 12 Interface Science 93–103 (2004).
1055	Wang et al., <i>70% TMR at Room Temperature for SDT Sandwich Junctions With CoFeB as Free and Reference Layers</i> , 40 IEEE Trans. Magn. 2269-2271 (2004)
1056	U.S. Patent Publication No. 2004/0136232A1 (“Hosomi”)
1057	Dieny et al., <i>Introduction to Magnetic Random-Access Memory</i> (IEEE Press 2017) (excerpts)
1058	Amodeo et al., <i>Dislocations and Plastic Deformation in MgO Crystals: A Review</i> , 8 Crystals 240 (2018)
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1060	Jimbo et al., <i>Thermal stability of spin valves using amorphous CoFeB</i> , 165 J. Magnetism & Magnetic Materials 308-311 (1997)
1061	Cardoso et al., <i>Ferromagnetic Coupling Field Reduction in CoFeB Tunnel Junctions Deposited by Ion Beam</i> , 40 IEEE Trans. Magn. 2272-2274 (2004)
1062	U.S. Patent No. 7,270,896 (“Parkin”)
1063	Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024) (without exhibits)
1064	Claim Chart for ’403 Patent, Exhibit D to Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024)

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1065	Claim Chart for '263 Patent, Exhibit E to Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024)
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Exhibit No.	Description
1076	Claim Chart for '134 Patent, Exhibit II to First Amended Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024)
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1082	U.S. Patent No. 8,427,791 ('791 Patent)
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1105	Reply Declaration of Jeffrey Bokor, Ph.D.
1106	Giordano et al., <i>Characteristics of Pd adsorption on the MgO(100) surface: Role of oxygen vacancies</i> , 64 Physical Review B 075417 (2001)

IP Bridge (“IPB”) has disclaimed Claims 1-4 and 7-8 of the ’909 Patent. EX2018. For the remaining claims, IPB contests only obviousness of the “barrier height” limitations: “a range of 0.1 eV to 0.85 eV” (Claims 5, 9-11, 13-14) or “a range of 0.2 eV to 0.5 eV” (Claims 6, 12, 15-20). The Petition explained that Soukup teaches or suggests a mechanism for reducing barrier heights of MgO into the claimed ranges, including reducing Bowen’s 0.9 eV barrier height into the claimed “0.1 eV to 0.85 eV” range, and specifically discloses an MgO barrier height of 0.33 eV within both claimed ranges.

IPB recently acquiesced to the Examiner’s finding the prior art “teaches a barrier height of (0.1 eV to 0.85 eV) and (.2eV to .5eV).” EX1086, 257; *id.*, 263 (IPB’s attorney informed examiner “the case has gone abandon[ed].”). In retreat, IPB argues secondary considerations of non-obviousness but fails to show nexus. IPB has neither distinguished Soukup because it is analogous prior art nor undermined the motivation to combine Soukup with Bowen or Nagahama. Because these claims should never have issued, Petitioner respectfully requests cancellation of the remaining ’909 patent claims.

I. IPB’S PURPORTED SECONDARY CONSIDERATIONS DO NOT REFUTE OBVIOUSNESS

IPB first tries to defend its patent by presenting the same alleged secondary considerations evidence for the barrier-height claims that it did for the MgO-CoFeB

claims in the '134/'167 IPRs. *Compare* POR, 20-29, with IPR2024-01447, Paper 19 ('134 POR), 60-71; EX1105 ¶¶70-71. This tacitly concedes the lack of any genuine nexus to the '909 claims.

“For objective evidence of secondary considerations to be accorded substantial weight, its proponent [IPB] must establish a nexus between the evidence and the merits of the *claimed invention*.” *In re Kao*, 639 F.3d 1057, 1068 (Fed. Cir. 2011) (emphasis original). Limitations “already in the prior art” cannot show nexus. *Id.* at 1069. IPB only argues the tunnel barrier height ranges were not disclosed in the prior art. *E.g.*, POR, 58-62. IPB’s “failure to link” its secondary considerations evidence “to the features of its invention that were not disclosed in [the prior art] undermines the probative force of [its] evidence.” *Asyst Techs. v. Emtrak*, 544 F.3d 1310, 1316 (Fed. Cir. 2008).

IPB’s purported industry praise and long-felt need is untethered to the '909 Patent claims and/or relates to limitations “already in the prior art.” *Kao*, 639 F.3d at 1069. IPB presents nothing showing its evidence pertains to the allegedly novel barrier-height ranges. *See* POR, 20-29.

A. No Nexus For Industry Praise

First, IPB alleges that inventor **Yuasa’s own publications** constitute evidence of industry praise. POR, 21-24; EX2053 ¶¶152-57 (citing EX2015, EX2016, EX2017, EX2021, EX1057). Such “self-referential commendations fall well short

of demonstrating true industry praise.” *See Bayer Healthcare v. Watson Pharms.*, 713 F.3d 1369, 1377 (Fed. Cir. 2013). IPB’s touting of Yuasa’s “bare journal citations” also “fall[s] well short of demonstrating true industry praise.” *Id.* at 1377; POR, 22 (citing EX2008); EX2053 ¶152; EX1105 ¶¶72-73.

IPB next cites **assorted publications** mentioning Yuasa. POR, 23-25. Nakatani/Gao’s (EX2022) reference to Yuasa’s demonstration of MTJs, “based on [the] theoretical prediction” of Butler/Mathon that “a TMR sensor with low resistance and high MR ratio [is] possible” utilizing coherent tunneling in Fe/MgO/Fe structures, credits Butler/Mathon and not Yuasa. EX2022, 107. Zhu/Park (EX2005) referenced Yuasa’s use of “molecular beam epitaxy (MBE)” to grow “Fe/MgO/Fe MTJs.” EX2005, 38. Marrows (EX2019) noted Yuasa’s use of “MgO barriers” and “pure Fe electrodes grown by MBE techniques.” EX2019, 591. Tsymbal/Fert (EX2020) likewise described Yuasa’s contribution as an “MgO MTJ of very high structural quality.” EX2020, 8. IPB does not contest that MgO barriers, Fe electrodes, and MBE are in the prior art, thus precluding their use as evidence of non-obviousness. *E.g.*, EX1026, 1655 (Fe(001)/MgO(001)/FeCo(001) MTJs); EX1027 ¶¶62 (MBE), 73 ((001)-oriented ferromagnetic and MgO barrier layers); EX1044, Abstract (“epitaxial Fe(100)|MgO(100)|Fe(100)”; EX1105 ¶74; *Kao*, 639 F.3d at 1068.

IPB also alleges **Yuasa’s awards** show industry praise, POR, 26-27, which yet again fails to show nexus to the claimed “*barrier height*,” EX1105 ¶75; *Kao*, 639 F.3d at 1068:

- EX2033, 1: Tsukuba Prize “for the first successful creation of a three-layer [MTJ]. . . composed of iron and MgO.”
- EX2032, 1: Tsukuba Prize for “experiments based on the theory that a very large MR ratio could be obtained by using crystalline magnesium oxide” instead of alumina.
- EX2029, 2: S&T Prize for “a new type of [MTJ]... using crystalline [MgO] as the tunnel insulating film.”
- EX2024, 3: JSAP Award for “MTJs combining MgO and [CoFeB] alloys in collaboration with Canon ANELVA.” This award references unnamed “technologies to reduce the resistivity of elements,” but does not link it to the barrier height limitations. *See id.*

B. No Nexus For Long-Felt Need

IPB next asserts the ’909 Patent satisfied a long-felt need for increased TMR where others had failed. POR 27-29; EX2053 ¶¶163-67. Yet IPB admits that this need was met in 2001 by Butler/Mathon, who proposed replacing alumina barriers with MgO to skyrocket TMR values. *See* POR, 28; EX2053 ¶165. This need was further met by Parkin’s earlier and independent development of MgO MTJs with

increased TMR. EX1105 ¶76; EX2022, 107 (“Parkin et al. demonstrated an MR ratio of 220%....”).

II. ONE OF SKILL WOULD HAVE COMBINED BOWEN OR NAGAHAMA WITH SOUKUP

There is no dispute that Butler/Mathon “predicted high TMR” in MgO MTJs. POR, 18. The Petition explained that Soukup provided a mechanism for skilled artisans to achieve high TMR by lowering barrier height through the introduction of oxygen vacancy defects in MgO barrier layers. IPB asserts patentability only of its two barrier-height-range limitations. IPB cannot credibly argue these limitations are patentable after acceding to the Examiner’s findings that the prior art teaches barrier heights of 0.1-0.85 eV and 0.2-0.5 eV, IPR2025-00701, Paper 8, 2 (citing EX1086, 257), and the Director finding “material error” when the same Examiner allowed these limitations in the ’138 Patent. IPR2025-00701, Paper 9, 2.

A. Soukup Taught A Mechanism For Exploring Lower Barrier Heights To Increase TMR

TMR unquestionably was one of the most important performance parameters for MTJs. Pet., 5. IPB agrees that “a high TMR was among the goals for an MTJ device,” POR, 32, and does not dispute that a skilled artisan was motivated to increase the TMR of MgO MTJs like Bowen and Nagahama, given the predictions of “higher TMRs” by Butler/Mathon, POR, 28; *see* EX1024 ¶¶68-69.

In view of this overwhelming and undisputed motivation supplied by Butler/Mathon, it is undisputed the Petition explained:

One of skill in the art looking to increase TMR of an MgO barrier would have been motivated to explore lower barrier heights to facilitate tunneling of parallel electrons.... [and] would have looked to Soukup's teachings....

Pet., 34-35 (citing EX1024 ¶171) (cited by POR, 31-32). Petitioner's expert Bokor further explained:

Butler and Mathon taught that MgO barriers would achieve higher TMRs due to improved symmetry matching between the MgO barrier and ferromagnetic electrodes, *facilitating tunneling of parallel electrons across the barrier compared to antiparallel tunneling*.

[Thus], skilled artisans would have been motivated to explore lower barrier heights to facilitate tunneling of parallel electrons.

EX1024 ¶¶170-71.

IPB attempts to dismiss Soukup as only “teach[ing] an alleged barrier height of 0.33 eV,” POR, 35, but the Petition and Bokor pointed out that Soukup more broadly taught a skilled artisan a mechanism for lowering barrier height in MgO: oxygen defects. Pet., 35 (citing EX1024 ¶171); *see also* EX1024 ¶172; EX2013, 187:15-188:14 (“Soukup is teaching a way that potentially you could really make a big change in the barrier height.”). Motivated to increase TMR, one of skill would

have sought to lower the barrier height of MgO in Bowen's and Nagahama's MTJs to fall within the claimed ranges of "0.1 eV to 0.85 eV" and "0.2 eV to 0.5 eV." Pet., 33-37, 57-59.

IPB unfairly criticizes Bokor's testimony that "a POSA would not have known whether lowering the barrier height of the MgO barrier layer in Bowen or Nagahama would have increased or decreased TMR." POR, 34. But Bokor explained that one of skill "would have had a reasonable expectation that the TMR would change" were barrier height lowered even if they were not "certain which way it would go." EX2013, 50:9-51:5, 51:23-52:5.

That is a legally sufficient motivation. A "court can take account of the inferences and creative steps that a person of ordinary skill in the art would employ." *KSR Int'l v. Teleflex*, 550 U.S. 398, 418 (2007). Bokor's explanation showed that lowering barrier height to improve TMR would have been "nothing more than routine' application of a well-known problem-solving strategy" stemming from "the normal desire of scientists or artisans to improve upon what is already generally known." *Pfizer v. Apotex*, 480 F.3d 1348, 1368 (Fed. Cir. 2007) (citation omitted). Butler's predictions about the behavior of parallel and antiparallel electrons crossing MgO rendered barrier height an identified and predictable (if uncertain) strategy to increase TMR. *Id.*; EX2014, 216:15-17 ("[I]f I think that there's a 50/50 chance I'm

going to get the improvement that I’m looking for, boy, oh, boy, I’m going to try that.”).

B. IPB’s Criticisms Of The Combination Have No Merit

IPB incorrectly argues that Bokor “ultimately conceded a POSA might have also expected it to have no impact on TMR.” POR, 34 (citing EX2014, 38:8-40:15, 214:18-216:19). Bokor made no such concession, instead explaining that one of skill “would expect... the TMR to vary with barrier height fairly strongly.” EX2014, 39:11-14; *id.*, 214:24-215:4 (One of skill “would have a very strong expectation that they would see some change in the TMR, not just zero.”). His testimony about TMR plots noted that sometimes “for small changes in barrier height, the change in TMR could be very small,” but did not concede that barrier height might have *no* impact on TMR. EX2014, 39:22-40:5.

Next, IPB claims Bokor admitted that neither his declaration nor the cited references say “that lowering barrier height would increase TMR.” POR, 35 (citing EX2013-EX2014). Bokor said the opposite: “To increase TMR of an MgO barrier, skilled artisans would have been motivated to explore lower barrier heights to facilitate tunneling of parallel electrons.” EX1024 ¶171; *see also, e.g.*, EX2013, 119:15-124:11 (discussing EX1024 ¶170).

IPB next alleges that the Petition made only a “single reference to compar[ing]” parallel and antiparallel states based on Butler/Mathon and claims

Bokor essentially admitted that Butler/Mathon “had nothing to do with barrier height.” POR, 36. IPB is simply incorrect. The Petition and Bokor explained how Butler/Mathon supplied the “motivat[ion] to explore lower barrier heights *to facilitate tunneling of parallel electrons*.” Pet., 34-35; EX2024 ¶171; *supra* §II.A. Symmetry matching between the electrodes and MgO that Butler identified meant that “[t]he tunneling resistance for the parallel’ electrons was ‘estimated to be 100 times smaller than that for the antiparallel’ electrons....” Pet., 12 (quoting EX1045, 1); *see also* EX1024 ¶¶68-69. This suggested to one of skill that “[i]t’s a different mechanism” for parallel versus antiparallel conduction in Butler/Mathon, EX2013, 116:16-19, and one of skill

would thereby change the energy at which the spins or the electrons are entering the barrier relative to the band structure. And... it is reasonable to expect that factor [of a hundred] will change... [because] as the tunnel barrier is reduced, that changes the energy alignments of the ferromagnetic electrode and the MgO.

EX2013, 116:20-117:9; *see also id.*, 120:5-124:11.

IPB misleadingly claims there is “no doubt” that “Bokor admitted that no prior art teaching he was aware of taught that lowering barrier height would increase TMR....” POR, 36-37. But IPB’s counsel clearly understood Bokor’s actual testimony to the contrary:

Q. *[W]hat you're saying is the POSA would have had a reasonable expectation that lowering the barrier height would increase TMR* because the POSA knew that TMR had to change and, look, it was either up or down, so 50/50, one of those would have increased TMR.... [I]s that your testimony?

A. That's my testimony.

EX2013, 154:1-8; *see also id.*, 188:11-189:6 (explaining a 50% chance TMR would increase with lower barrier height).

C. IPB's Discredited Argument That Slonczewski Taught Avoiding Lower Barrier Heights For MgO MTJs

IPB next relies on the Slonczewski model to argue that one of skill would have expected lower barrier heights would lower TMR for MgO. POR, 37-43. It criticizes Bokor for explaining that a skilled artisan would understand that Slonczewski's simple model for generic barriers was inapplicable to MgO. POR, 42. But the experts agree that (1) Slonczewski's model never accounted for MgO's different tunneling mechanism, and (2) Butler himself labeled Slonczewski "inadequate" for MgO. EX1105 ¶¶24-26, 57-58; EX1102, 71:12-73:11, 80:22-83:13.

It is no surprise that Slonczewski's simple model did not consider the complexities of using MgO as a barrier layer. Slonczewski was published in 1989. EX2041, 6995. The first successful MgO MTJ was built around 2000. EX1105

¶¶27-28; EX1102, 69:15-70:14; *see also* EX1043, 1; EX1047, 509 (describing same).

Ross called Butler’s 2001 paper about MgO MTJs “extremely famous,” EX1102, 20:4-6, because Butler predicted that MgO MTJs would use “a different mechanism of tunneling compared to the simple models described by previous authors like Simmons,” EX1102, 45:14-46:4; EX1105 ¶¶13-16. Ross conceded that Butler’s MgO model recognized that electrons with specific symmetries in the electrodes would preserve that symmetry through evanescent states in the MgO barrier, such that different electrons with different symmetries and different spins would decay at different rates. EX1102, 47:6-50:13; EX1105 ¶¶17-23. Ross also conceded that because electrons tunnel randomly through amorphous alumina barrier layers, they had been successfully modeled by ignoring the effect of electron symmetries on tunneling conductance. EX1102, 53:12-55:20; EX1105 ¶¶50-51.

Butler’s MgO barrier “results indicate that tunneling is much more interesting and complicated than the simple barrier model used previously” for alumina barriers. EX1044, Abstract; *id.*, 7 (“[W]e showed contrary to [the simple barrier] model, that states with different symmetry decay at different rates as they tunnel through the barrier.”). The experts agree that Slonczewski’s model ignores that MgO conducts different electron symmetries and spins at different rates. EX1102, 72:5-73:11; EX1105 ¶¶29-31; *see also* EX1102, 80:22-85:17 (Ross: conceding Butler’s

statement that prior models were “completely inadequate for understanding tunneling” fully applies to Slonczewski). In fact, Slonczewski’s model is based on the same Equation (9) that Butler characterizes as the simple barrier model. EX1105 ¶¶32-39 (comparing EX1044, 7 (Equation (9)) with EX1057, 14); EX1102, 85:18-86:16 (Ross: offering “no opinion on it”).

One of skill having read Butler would conclude that Slonczewski’s model was “completely inadequate for understanding tunneling” in MgO. EX1044, 1; EX1105 ¶39. IPB’s citations to Moodera 1995 (EX1035), Moodera 1996 (EX1038), and Saito (EX2037) that all expressly cite or track Slonczewski’s outdated model are plainly insufficient to show how one of skill, *after* Butler in 2001, would have predicted the impact of barrier height on TMR in MgO. POR, 37-38 (IPB: Moodera “discusses a 1989 theory by Slonczewski” and Saito used “a model ‘roughly consistent’ with Slonczewski’s theory.”); *see also* POR, 37-42; EX1105 ¶¶40-52; EX1102, 78:14-79:8 (Ross: “Saito uses Slonczewski’s model with all of its approximations”). Aside from the outdated model, Saito’s experimental data was based on an alumina barrier “inadequate” to predict MgO barrier behavior. EX1044, 1; EX2037, L1035 (describing fabricating MTJs with alumina barriers); EX1102, 53:12-55:20 (alumina barriers could be understood by “very simple model”); EX1105 ¶¶48-52; *see also* POR, 38-41. Finally, Yuasa’s citation to Saito’s simplistic model that “for an *Al-O* tunnel barrier height, a lower barrier height yields a lower

MR ratio,” POR, 39-40 (quoting EX2017, 869), would not convince a skilled artisan that *MgO* responds similarly. EX1105 ¶¶53-54, 57-58; EX1102, 53:12-55:20.

D. The Claimed 0.1-0.85 eV Barrier Height Was Obvious

IPB claims the Petition’s only theory was that one of skill would combine Bowen or Nagahama with Soukup’s 0.33 eV barrier height. POR 30, 45. Yet it acknowledges that Ground 1 explained “the claimed 0.1-0.85 eV range ‘is only slightly below’ Bowen’s alleged barrier height of 0.9 eV.” POR, 43 (citing Pet., 35). The Petition explained that a skilled artisan was motivated to “explore lower barrier heights.” Pet., 35. Given the conceded motivation to increase TMR and the logic behind reducing barrier height to do so, *supra* §II.A, decreasing barrier height from 0.9 eV to 0.85 eV to arrive at Claims 5, 9-11, and 13-14 required very little. EX1024 ¶173; *id.* ¶¶165-80, 272-86.

Asserting the Petition never established a “reason why” one of skill would lower Bowen’s barrier height 0.05 eV to within the claimed range, POR, 43-44, is disingenuous when IPB concedes the Petition provided a reason on the same page: “a POSA would have lowered the barrier height to ‘improve TMR,’” POR, 44 n.12 (quoting Pet., 35-36).

E. Lower Barrier Heights Were Obvious

IPB argues that Butler’s motivation to lower barrier height to increase TMR is a “new theory” that “should not be considered.” POR, 47; *id.*, 47-51. Yet IPB

never bothers to show that any of Bokor’s specific testimony elicited on cross-examination constitutes a new theory or was not adequately presented in the Petition.

See POR, 47-48. Instead, IPB rehashes its prior arguments:

- IPB tries to refute Bokor’s testimony with Slonczewski’s teachings “that lowering barrier height would decrease TMR,” POR, 48-49, but the experts and Butler agree that Slonczewski is “completely inadequate” for MgO. *Supra* §II.C.
- IPB argues Bokor testified that “Butler [taught] barrier height would have no impact on TMR at all.” POR, 50. But Bokor explained one would expect “TMR to vary with barrier height fairly strongly.” EX2014, 39:11-14; *supra* §II.B (citing EX2013, 116:20-117:9, 120:5-124:11).

IPB relies on Ross’ opinion that “Butler does not provide any data for any structure other than the one the authors modeled and a POSA would not have drawn any conclusions beyond those reached by Butler....” EX2053 ¶96 (cited by POR, 50). In fact, Butler provides data leading one of skill to conclude that lowering barrier height would change TMR.

There’s no dispute that barrier height is the difference between the MgO insulator’s conduction band and the Fe electrode’s Fermi level. POR, 14; EX2053 ¶65; EX1024 ¶48; EX1102, 29:12-18. Butler’s Figures 3-4 depict the different majority- and minority-spin densities of states (“DOS”) surrounding the Fermi

energy in Fe and MgO near the Fe-MgO interface, which represents the capacity of electrons to tunnel. EX1044, 2-3; EX1105 ¶¶10-12; *see also* EX2053 ¶87. Butler explains for these figures:

Near the interface the majority DOS is strongly reduced in the vicinity of the Fermi energy whereas for the minority spin channel the Fermi energy falls near a sharp peak in the DOS.

EX1044, 3. One of skill could not help noticing that moving the Fermi energy level, for example, by reducing barrier height, would have a significant impact on tunneling conductance for both majority and minority spin channels, thus changing TMR. *Id.*; EX1105 ¶¶10-12. Ross explains why: “The TMR effect is known to originate from... the difference between the densities of states (DOSs) of the up- and down-spin subbands in the two electrodes.” EX2053 ¶135 (quoting EX1050, 2427).

“A person of ordinary skill is also a person of ordinary creativity, not an automaton.” *KSR*, 550 U.S. at 421. This person would readily understand from Soukup that the Fermi energy can be changed by introducing oxygen defects. EX1028, 3229; *see also* EX1105 ¶¶7-9, 67; EX1106, Abstract, 4-5, Fig. 5. Ross incorrectly asserts that “Butler does not provide *any data* for any structure other than the one the authors modeled,” EX2053 ¶96, but, as discussed, Butler’s Figures 3-4 showed the relationship between majority- and minority-spin-densities of states and the Fermi level and thus the potential impact of changing that level (by, for example,

introducing oxygen defects), EX1044, 3-4, Fig. 3; EX1105 ¶¶10-12. Given Ross’s own testimony about TMR originating in these spin densities, EX2053 ¶135 (quoting EX1050, 2427), an ordinarily skilled artisan of course would have expected TMR to change by introducing oxygen defects to adjust barrier height. *KSR*, 550 U.S. at 421.

III. SOUKUP IS ANALOGOUS ART

Despite Soukup’s focus on MgO barrier layers just like the ’909 Patent, IPB argues that Soukup is not analogous to the Patent. POR, 51-58. This argument fails because Soukup is plainly from the same field of endeavor, or at the very least reasonably pertinent to the particular problem addressed by the ’909 Patent. *In re Bigio*, 381 F.3d 1320, 1325 (Fed. Cir. 2004) (setting forth “[t]wo separate tests” for analogous art).

A. Soukup Is In The Same Field

IPB’s restrictive view of the ’909 Patent is unsupported. *See* POR, 51-54. The Board must exercise “*common sense*... in deciding in which fields a person of ordinary skill would reasonably be expected to look for a solution.” *Bigio*, 381 F.3d at 1326 (emphasis original) (toothbrush analogous to patented hair brush).

The parties agree the ’909 Patent concerns MTJs “with a high magnetoresistance.” POR, 52 (quoting EX1017, 1:33-41). Low magnetoresistance hinders an “MTJ device using an amorphous Al-O as the tunnel barrier” from “be[ing] employed for an actual memory device.” EX1017, 2:52-61. For this

reason, the patent focuses exclusively on MTJs with MgO barriers. *E.g.*, EX1017, Abstract, 3:5-4:8, Figs. 1B, 11, Claims 1/9/15.

Given the '909 Patent's exclusive focus on MgO for high TMR, its field includes art describing current-voltage characteristics of MgO barriers. EX1105 ¶¶59-66. Soukup evaluates exactly that: current flow mechanisms through MgO barriers, including tunneling and Schottky emissions. EX1028, Abstract ("voltage-current characteristics of Au-MgO-Au thin-film emission diodes"), 3229 (tunneling according to Simmons). Soukup describes how to manipulate barrier height in MgO barriers using oxygen vacancies as described and required by Claims 1-8 of the '909 Patent. EX1017, 3:5-61, 10:6-7 (MgO_x "(0<x<1)"), 7:19-23 (achieving low barrier heights using oxygen defects).

IPB argues Soukup cannot be in the same field because it used non-magnetic electrodes. POR, 51-54. This construes the field too narrowly—so narrowly that IPB's expert refused to ratify it. Both the '909 Patent and Soukup:

- describe an MgO film sandwiched between conductive electrodes. EX1017, 5:53-56; EX1028, 3229 (referencing "metal-insulator-metal sandwich devices"); EX1024 ¶¶83, 96; EX2053 ¶104; EX1105 ¶64.
- address the barrier height of conductor-insulator junctions. EX1024 ¶¶84, 98; EX1105 ¶64.

- recognize tunneling as a conduction mechanism. EX1028, 3229; EX1024 ¶¶45, 83, 96; EX1105 ¶64.

IPB's constricted view of the field only results in nonsensical outcomes. For example, Simmons' seminal paper (EX1031) was published before the discovery of MTJs, EX1102, 27:9-22, yet provided an early tunneling model that both the '909 Patent and IPB rely on, *e.g.*, EX1017, 7:39-52, 8:3-14; POR, 72. Crediting IPB's argument would foolishly exclude Simmons as analogous art because it does not describe magnetic electrodes, EX1105 ¶64, an outcome even Ross was unwilling to endorse, EX1102, 24:9-25:9.

IPB cannot sustain its claim that Soukup did not concern tunneling, POR, 53-54, admitting at least one of Soukup's MgO devices likely exhibited tunneling, POR, 59; EX1102, 41:16-42:5; EX1028, 3232-33. Soukup's observation that the other devices' conduction mechanisms "could very well be... a Schottky-type process," EX1028, 3235, does not change Soukup's findings about barrier height or controlling barrier height using oxygen defects. Ross admits Soukup and the '909 Patent define the same barrier height, and determining barrier height requires using the correct equation for the type of current flow. EX1102, 32:7-10, 43:3-44:8. Skilled artisans exercising ordinary creativity would consider Soukup analogous to the '909 Patent. EX1105 ¶66.

B. Soukup Is Reasonably Pertinent To The Problem

Alternately, Soukup constitutes analogous art because it is reasonably pertinent to the problem the '909 Patent sought to solve. POR, 56-57; *Bigio*, 381 F.3d at 1325-26.

IPB re-asserts that Soukup's devices "were not magnetic" and "not tunneling," *compare* POR, 56-57, *with* POR, 53-54. IPB's recycled arguments are even weaker for the field of endeavor test, *supra* §III.A; EX1105 ¶67, because "familiar items may have obvious uses beyond their primary purposes" and analogous art must be construed "broadly." *Wyers v. Master Lock*, 616 F.3d 1231, 1238 (Fed. Cir. 2010) (quoting *KSR*, 550 U.S. at 402).

It is undisputed the '909 Patent sought to increase TMR, EX1017, 1:35-40, 2:52-61, and its claimed solution lay in the adoption of MgO barriers, EX1017, Abstract, 3:5-4:8, Figs. 1B, 11, Claims 1/9/15; *see also* POR, 55-56. Soukup addressed conductor-insulator junctions with MgO barriers, teaching how to manipulate barrier height to alter the junctions' electrical properties. EX1028, 3229; EX1024 ¶¶171, 174, 273-74. Given that Soukup is directly related to MgO barriers with oxygen defects—the same solution the '909 Patent adopts and claims—Soukup was a reasonably pertinent reference. *Wyers*, 616 F.3d at 1238. IPB's assertion that "[n]o practitioners... considered Soukup relevant," POR, 57, improperly considers

their “subjective intent or knowledge,” *In re Singhai*, 602 F. App’x 826, 830 (Fed. Cir. 2015) (unpublished).

IV. COMBINING BOWEN AND NAGAHAMA WITH SOUKUP LED TO MTJs WITH THE CLAIMED BARRIER HEIGHTS

A. One Of Skill Would Have Adopted Soukup’s Reported Barrier Heights In Bowen And Nagahama

IPB criticizes Soukup’s 0.33 eV barrier height measurement as “too low,” POR, 60, and argues that crediting it mandates adoption of a trend between oxygen defects and barrier height contradicting the motivation to combine. POR, 58-60, 67-69. Both assertions misconstrue Soukup.

1. Soukup Taught An Inverse Correlation Between Barrier Height And Oxygen Defects

Soukup’s article and thesis observed an inverse relationship between oxygen defects and MgO barrier height. The parties largely agree regarding what Soukup taught:

- Soukup determined the barrier heights of insulator-conductor devices using models appropriate to the observed conduction mechanism to calculate barrier height. EX1028, 3229; POR, 59 (“Soukup compared the *I-V* characteristics to models for different known current-flow mechanisms....”).
- Soukup observed that 12 devices might “very well” have experienced Schottky conductance, POR, 59; EX1028, 3235, and accordingly applied the

Schottky model to determine barrier height, EX1028, 3231-32; *see also* POR, 59-60.

- Soukup first calculated barrier height using the “zero-field intercept” method, EX1028, 3231, Fig. 4; POR, 60.
- Soukup next calculated barrier height using the “Arrhenius plot” method, EX1028, 3232, Fig. 5; POR, 60.

IPB does not address Soukup’s specific findings. POR, 59-60. For sample **PY-G-11(1)**, Soukup found a barrier height of 0.71 eV using the zero-intercept method and 0.33 eV using the Arrhenius plot. EX1028, 3233, Table 1. He noted the Arrhenius plot was valid for sample PY-G-11(1) because it showed an expected linear plot in Figure 5. EX1028, 3232 (plot should be straight and is straight in the case of Figure 5); EX2053 ¶107 (“Soukup... notes that the plot is a straight line.”).

But for two other devices Soukup used to assess the effect of MgO non-stoichiometry, **PY-G-22(2)/PY-G-25(3)**, EX1028, 3232, the results were suspect because the zero-intercepts plotted as straight lines, EX1028, 3232, but the Arrhenius plots did not, EX1028, 3234, Fig. 12; *see also id.*, 3232 (Fig. 5 straight but most Arrhenius plots were not). A skilled artisan like Soukup would not have relied upon the Arrhenius plots for PY-G-22(2)/PY-G-25(3) due to their non-linearity. EX1028, 3232 (adopting the zero-intercept non-stoichiometry data for PY-G-22(2)/PY-G-

25(3), 3236 (“a higher barrier for larger amounts of oxygen present”); EX2013, 169:4-171:20.

Soukup’s earlier Ph.D. thesis came to the same inverse-relationship conclusion: “The [barrier height] change was to a higher barrier as the oxygen pressure was made higher [i.e., defects were reduced].” EX2039, 112. Soukup explained the phenomenon thusly: “The excess Mg present [when there are oxygen vacancies] gives rise to [electron] donor levels... near the conduction band so that the barrier is quite low.” EX2039, 112. Simply put, as MgO transitions into metallic Mg, barrier height necessarily decreases. EX1024 ¶174.

2. Soukup Taught Lower Barrier Heights

IPB contends that Soukup’s thesis criticized his barrier heights as “too low” because the PY-G-11(1) Arrhenius plot was not straight. POR, 67 (citing EX2039, 88-89); EX2053 ¶¶107-109 (discussing thesis Fig. 39).

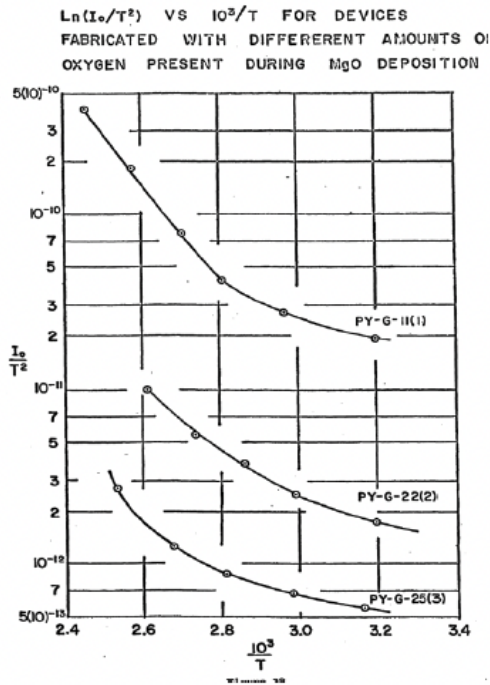


Figure 39
Soukup's 1969 Thesis (EX2039)

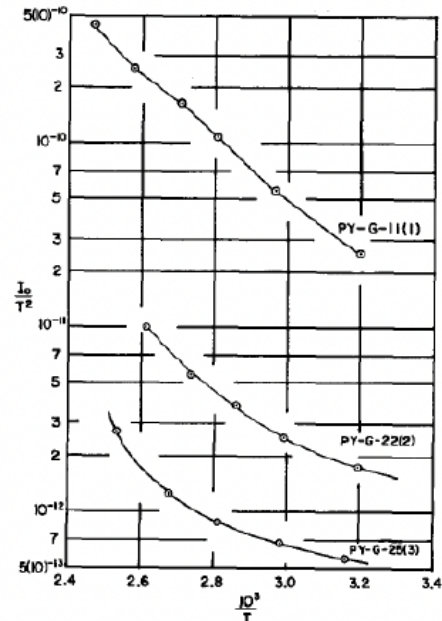


FIG. 12. Ln(I_0/T^2) vs $10^3/T$ for devices fabricated with different amounts of oxygen present during MgO deposition.

Figure 12
Soukup's 1970 Paper (EX1028)

As shown above, Figure 39 in Soukup's 1969 thesis plainly shows different data for PY-G-11(1) than presented in his 1970 paper. EX1105 ¶68. Ross's critique that "PY-G-11(1) also did not produce a straight-line Arrhenius plot" in the thesis, EX2053 ¶109, contradicts her earlier acknowledgement that "Soukup explains that an Arrhenius plot... is made in Fig. 5 and notes that the plot is a straight line," EX2053 ¶107 (noting this is the source of 0.33 eV barrier height). One of skill would conclude that Soukup corrected the PY-G-11(1) data before publication in his 1970 paper. EX1105 ¶¶68-69.

As explained, Soukup provided the mechanism (oxygen defects) to accomplish a skilled artisan's motivation to increase TMR using lower barrier

heights with a reasonable probability of success. *Supra* §II.A. Bokor explained how one of skill would have viewed Soukup:

Barrier heights as low as .7 are highly likely. Even possibly as low as .3 -- .33. And so this seems to be promising. I should try repeating this [in an MTJ] and see what I get.

EX2013, 186:3-21; *see also id.*, 188:2-10 (“I want the higher TMR so much that I’m willing to... give it a good try.”), 189:3-6 (50% chance TMR would increase). Given the industry’s undisputed high motivation for higher TMRs, POR, 31-32, one of skill would have followed Butler’s teachings to lower barrier height, *supra* §II.A; EX1024 ¶¶170-72. Bokor’s testimony and the art prove a reasonable expectation of success, *supra* §II, and there is no valid dispute that once attempted, the skilled artisan would have succeeded in meeting the claims, *see* POR, 67-69.

B. Soukup’s Barrier Heights Are Compatible With Bowen’s And Nagahama’s MTJs

According to IPB, Soukup would not have motivated one of skill to lower barrier height because Bowen’s/Nagahama’s MTJs relied on tunneling conductance, had magnetic electrodes, and therefore possessed an intrinsic TMR, all of which Soukup’s devices purportedly lacked. POR, 60-63. IPB again incorrectly assumes that one of skill was unable to learn from a reference describing non-MTJs like, for example, Simmons. *Supra* §III.A. Aside from being legally incorrect, IPB ignores that the motivation to lower barrier height comes from the knowledge of one of skill

based on references like Butler/Mathon, Pet., 34-35, and Soukup provides the mechanism in the form of introducing oxygen defects, which it undoubtedly teaches for MgO, EX1024 ¶¶168; EX1028, 3232; *supra* §II.A.

That Soukup itself was not an MTJ with magnetic electrodes and TMR is irrelevant to a skilled artisan’s motivation and the resulting combination. EX1105 ¶¶61-67. Ross admits that barrier height is an intrinsic property of every insulator-conductor junction. EX1102, 29:12-18. Insulator-conductor junctions like Soukup’s Au-MgO junctions have barrier heights just as much as the Bowen/Nagahama ferromagnetic-MgO junctions do. *Id.* There is no serious dispute that Soukup’s barrier height teachings for MgO can inform the barrier heights of other MgO insulator-conductor junctions, including in MTJs. EX1105 ¶¶61-67; EX1102, 32:7-10. Skilled artisans are not automatons, but rather persons of ordinary creativity. *KSR*, 550 U.S. at 421.

C. Soukup’s 0.33 eV Barrier Height Would Not Transform Bowen’s And Nagahama’s MTJs Into Schottky Devices

IPB next argues a skilled artisan would not have adopted Soukup’s barrier heights in Bowen/Nagahama for fear of transforming their MTJs into Schottky devices with low TMR. POR, 63-67. But Ross attributes this result to Soukup’s thick barrier: “Schottky emissions were the dominant current flow mechanism in Soukup’s devices” and “[g]iven that Soukup’s oxide thicknesses were from 3 to 34

times as thick as the MgO layer in the '909 Patent, [that] would have been unsurprising to practitioners in the 2004 timeframe.” EX2053 ¶129 (citing EX1028, 3232, 3233 (Table I)). Bowen/Nagahama, in comparison, had MgO thicknesses the same or less than the '909 Patent. EX1026, 1656-57 (2 nm); EX1027 ¶41 (2 nm); EX1017, 6:50-54 (2 nm). Butler confirms Ross’ opinion that MgO barriers must be no more than a few nanometers in thickness to show large TMR. *E.g.*, EX1044, 1 (MgO 5-atoms-thick), Fig. 7 (modeling MgO 8-atoms-thick).

D. Introducing Oxygen Defects Does Not Contradict Bowen Or Nagahama

IPB next argues that Soukup’s oxygen-defect mechanism for lowering barrier height subverted the teachings of Bowen and Nagahama that allegedly sought “a perfect defect-free crystalline MgO layer.” POR, 69-70. IPB does not dispute that a skilled artisan knew that oxygen defects are naturally and intrinsically present in oxides. Pet., 13; EX1024 ¶73. Bowen explicitly recognized the potential “presence of stoichiometric... inhomogeneities” (i.e., oxygen defects) in its barrier layers. EX1026, 1656; Pet., 24; EX1024 ¶¶82, 134.

One of skill further recognized that devices could still function as MTJs notwithstanding the defects. EX1026, 1655-56 (“[c]ontinuous and good crystal quality MgO films with sharp interfaces” obtained notwithstanding “stoichiometric ... inhomogeneities”); EX1045, 1, 8 (“nearly perfect crystalline MgO(001) films”

obtained notwithstanding “a low density of local defects”); EX1047, 509, 511 (“high quality” MgO film obtained notwithstanding “low” “density of electronic defects in the barrier”).

Even if some level of oxygen defects were harmful, which IPB fails to show, POR, 69-70, one of skill recognizing the benefit of lower barrier height would still be motivated to use them. *Novartis v. Torrent Pharms.*, 853 F.3d 1316, 1327-28 (Fed. Cir. 2017) (affirming obviousness where Board considered reference’s benefits and disadvantages); *Hoffman-La Roche v. Apotex*, 748 F.3d 1326, 1333 (Fed. Cir. 2014) (increased side effects insufficient to teach away from increased dosage that provided other benefits).

E. Soukup Measured Barrier Height

Finally, IPB argues that Soukup did not measure “tunnel barrier height” as recited in the claims. POR, 72-73. (The claims recite “barrier height,” not “tunnel barrier height.” EX1017, Claims 5-6, 9-20.) The parties agree that “barrier height” is “the energy difference in electron volts (eV) between the Fermi energy (E_F) of the electrode material and the bottom of the conduction band of the barrier material.” POR, 14; Pet., 8-9. As Ross concedes, Soukup measured that. EX1102, 30:5-32:10 (Soukup defines barrier height the same as the ’909 Patent); EX2039, 125; EX1017, 3:24-28.

IPB asserts that “barrier height” must be measured using Simmons’ equation, POR, 72, but Ross testified that Simmons’ measurement of “barrier height” is inaccurate if tunneling does not dominate current flow, as observed in Soukup, EX1102, 41:16-44:8.

V. CONCLUSION

Petitioner respectfully requests cancellation of Claims 5-6 and 9-20 of the ’909 Patent.

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CERTIFICATE OF COMPLIANCE

Pursuant to 37 C.F.R. § 42.24(d), the undersigned certifies that foregoing **PETITIONER’S REPLY TO PATENT OWNER’S RESPONSE** exclusive of the parts exempted as provided in 37 C.F.R. § 42.24, contains 5,596 words and therefore complies with the type-volume limitations of 37 C.F.R. § 42.24.

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CERTIFICATE OF SERVICE

The undersigned certifies that pursuant to 37 C.F.R. § 42.6(e), a true copy of the foregoing **PETITIONER’S REPLY TO PATENT OWNER’S RESPONSE and EXHIBITS 1086, 1101-1102, 1105-1106** are being served electronically on October 8, 2025 to the following counsel for Patent Owner to the following email addresses:

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