

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

Patent No. 11,968,909

PATENT OWNER'S RESPONSE

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LISTING OF EXHIBITS

Exhibit	Description
2001	Kittel, C., <i>Introduction to Solid State Physics</i> , 6th Edition, 1986, pgs. 13-15, 18, 23 (“Kittel”)
2002	Duke, C.B., <i>Tunneling in Solids</i> , Solid State Physics: Advances in Research and Applications, 1969, pgs. 1, 6-7, 34-35, 78-79 (“Duke”)
2003	Definition of “ferromagnetism,” Oxford English Reference Dictionary, Second Edition, pg. 513 (“Oxford English Reference Dictionary”)
2004	“Ferromagnetism,” The New Encyclopaedia Britannica: Volume 4, 15th Edition, 2003, pgs. 748-749 (“Britannica”)
2005	Zhu, J.G., et al., <i>Magnetic tunnel junctions</i> , Materials today, Volume 9, Number 11, November 2006, pgs. 36-45 (“Zhu”)
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2007	Hard disk Market – Global Industry Analysis and Forecast (2025-2032), https://www.maximizemarketresearch.com/marketreport/global-hard-disk-market/63888/
2008	Yuasa citations, https://scholar.google.com/citations?view_op=view_citation&hl=en&user=kb5EQcsAAAAJ&citation_for_view=kb5EQcsAAAAJ:3fE2CSJlrl8C
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2010	Wang, S.X., et al., <i>Magnetic Information Storage Technology</i> (Academic Press 1999) (Chapter 6)
2011	RESERVED
2012	Parkin, S.P, et al., <i>Giant tunneling magnetoresistance at room temperature with MgO (100) tunnel barriers</i> , Nature Materials, 3 (2004), 862-867
2013	Transcript of Deposition of Jeffrey Bokor, Ph.D. (June 24, 2025)
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2015	Djayaprawira, D., et al., <i>230% room-temperature magnetoresistance in CoFeB/MgO/CoFeB magnetic tunnel junctions</i> , Applied Physics Letters, 86(9) (2005)

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2016	Yuasa, S., et al., <i>High Tunnel Magnetoresistance at Room Temperature in Fully Epitaxial Fe/MgO/Fe Tunnel Junctions due to Coherent Spin-Polarized Tunneling</i> , Japanese Journal of Applied Physics, 43(4B), (2004) L588
2017	Yuasa, S., et al., <i>Giant room-temperature magnetoresistance in single crystal Fe/MgO/Fe magnetic tunnel junctions</i> , Nature Materials, 3(12) (2004), 868-871
2018	Statutory Disclaimer Under 37 C.F.R. § 1.321(a)
2019	Marrows, C.H., <i>Spin-polarised currents and magnetic domain walls</i> , Advances in Physics, 52(8), (2005) 585-713
2020	Tsymbal, E., et al., <i>Handbook of Spin Transport and Magnetism</i> , 2012
2021	Nagamine, Y, et. al., <i>Ultralow resistance-area product of $0.4 \Omega (\mu\text{m})^2$ and high magnetoresistance above 50% in CoFeB/MgO/CoFeB magnetic tunnel junctions</i> , Applied Physics Letters, 89 (2006), 16507
2022	Nakatani, T., et al., <i>Read sensor technology for ultrahigh density magnetic recording</i> , MRS Bulletin, Materials Research Society, 43(2), (2018) 106-111
2023	Jiang, B., et al., <i>Tunneling magnetoresistive devices as read heads in hard disk drives</i> , Journal of Magnetism and Magnetic Materials, 571 (2023) 170546
2024	The 23rd (FY2022) Japan Society of Applied Physics Achievement Award Recipients (with English translation), The Japan Society of Applied Physics, https://www.jsap.or.jp/outstanding-achievementaward/recipients/recipients23
2025	JSAP Outstanding Achievement Award Recipients, The Japan Society of Applied Physics, https://www.jsap.or.jp/english/awards/outstanding-achievementaward/recipients
2026	2021 New Fellows, IEEE Japan Council, https://ieeep.org/en/kaiin/fellow/fellow21.html
2027	JST owned patent wins Future Creative Invention Prize at the National Invention Award 2021, Japan Science and Technology Agency, https://www.jst.go.jp/report/2021/210525_e.html
2028	Dr. Shinji Yuasa profile, https://www.jst.go.jp/impact/sahashi/en/system/index.html
2029	AIST wins three Science and Technology Awards in the 2016 Minister of Education, Culture, Sports, Science and Technology Commendation for Science and Technology,

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2030	Yuasa, S., <i>Magnetoresistance and Spin-Transfer Torque in Magnetic Tunnel Junctions</i> , IEEE Transactions on Magnetics, IEEE Magnetics Society Distinguished Lecturers for 2012, Vol. 48, No. 1, 2012
2031	Shinji Yuasa – IEEE Magnetics Society, https://ieeemagnetics.org/contact/shinji-yuasa#biography
2032	AIST: 20th Tsukuba Prize winner, https://www.aist.go.jp/aist_j/news/prize/itemid025-000077.html
2033	Announcing the winners for “Tsukuba Prize,” “Esaki Leona Prize,” and “Tsukuba Encouragement Prize”: Ibaraki Prefectural Science and Technology Promotion Foundation (with English translation), https://www.tsukuba-sci.com/cms/?p=9853
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2038	Maat, S., et al., <i>Physics and Design of Hard Disk Drive Magnetic Recording Read Heads</i> , Handbook of Spintronics, 2014
2039	Soukup, R.J., <i>Hot Electron Transport in Vacuum Deposited Thin Film Emission Diodes</i> , University of Minnesota, Ph.D., Physics, solid state, 1969, pgs. 1-209 (“Soukup-Dissertation”)
2040	U.S. Patent Application Publication No. 2006/0003185 A1
2041	J. C. Slonczewski, <i>Conductance and exchange coupling of two ferromagnets separated by a tunneling barrier</i> , Phys. Rev. B 39, 6995-7002 (1989)
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2043	RESERVED
2044	RESERVED
2045	RESERVED
2046	RESERVED
2047	RESERVED
2048	RESERVED

Exhibit	Description
2049	RESERVED
2050	RESERVED
2051	RESERVED
2052	RESERVED
2053	Declaration of Caroline A. Ross, Ph.D.
2054	<i>Curriculum Vitae</i> of Caroline A. Ross, Ph.D.
2055	U.S. Application No. 10/824835 File History (Partial)
2056	Citations to Butler: https://scholar.google.com/scholar?hl=en&as_sdt=0%2C22&q=Butler+et+al.%2C+Spin-dependent+tunneling+conductance+of+Fe%7CMgO%7CFe+sandwiches%2C+63+Phys.+Rev.+B+054416+%282001%29&btnG=
2057	Citations to Soukup: https://scholar.google.com/scholar?hl=en&as_sdt=0%2C22&q=Soukup+et+al.%2C+Voltage-Current+Characteristics+for+Electrical+Conduction+Through+Thin+MgO+Films%2C+41+J.+Appl.+Phys.+3229-+3236+%281970%29&btnG=
2058	Errata to EX2013
2059	Errata to EX2014

I. INTRODUCTION

Patent No. 11,968,909 (“’909 Patent”) is directed to “magnetic tunnel junction” (“MTJ”) devices. Every claim recites a magnetoresistive device comprising first and second ferromagnetic material layers and a tunnel barrier layer in between. The tunnel barrier layer has a “tunnel barrier height” of 0.1-0.85 eV in some claims and 0.2-0.5 eV in others.

The Petition’s two grounds are obviousness grounds both relying on a primary reference that discloses an MTJ device but does not disclose a tunnel barrier height within either claimed range. Both grounds rely on the same secondary reference “Soukup” to purportedly teach a tunnel barrier height of 0.33 eV. Both grounds assert that a POSA would have been motivated to achieve Soukup’s alleged lower barrier height of 0.33 eV in the primary reference’s MTJ device for a single reason—to increase the MTJ device’s tunnel magnetoresistance ratio (“TMR”). *No evidence* supports Petitioner’s assertion that a POSA would have expected that lowering the barrier height would have increased TMR.

TMR is the difference between the device’s resistances in its antiparallel (R_{ap}) and parallel (R_p) states normalized by R_p . Petitioner alleges that “[a]ccording to the [below] equation for TMR, lowering the resistance (barrier height) for parallel electrons (R_p) would improve TMR.” Petition, 34. Petitioner ignores the impact of lowering the barrier height on R_{ap} . It is undisputed that lowering the

barrier height would not increase TMR unless it **lowered R_p proportionally greater than it lowered R_{ap}** . Petitioner does not even allege that this was so, let alone submit evidence proving it was so.

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

At institution, the Board “disagree[d]” because the Board preliminarily found that Petitioner’s expert testified in EX1024, ¶169 that lowering the barrier height would have lowered R_p compared to R_{ap} . DI, 17. At deposition, Petitioner’s expert admitted he did not say that in ¶169. EX2013, 133:11-20. In fact, Petitioner’s expert repeatedly testified that a POSA would **not** have known whether lowering the barrier height would have increased or decreased TMR. *See e.g.*, EX2013, 51:10-22 (Q: “So a person of ordinary skill in the art in 2004 could **not** have said that the TMR would have increased or decreased; is that right? A: That’s what I’m saying.”).¹

Both obviousness grounds are premised on the assertion that a POSA would have lowered the barrier height in the primary reference to improve (i.e., increase) TMR. Yet, Petitioner’s expert not only refused to defend that assertion—he refuted it. He testified repeatedly that, contrary to the Petition’s assertion, a POSA in 2004 would not have known whether reducing the barrier height would have increased

¹ All emphasis is added unless otherwise indicated.

TMR, decreased TMR or had no effect on TMR. *See infra* §V.B.3 (collecting citations). Because Petitioner’s unsupported assertion that a POSA would have lowered the barrier height to increase TMR is the **only** basis the Petition offered for modifying its primary references, Petitioner’s failure to support that assertion with **evidence** is fatal to both grounds.

Both grounds also fail because Soukup would not have motivated a POSA to modify the primary references’ MTJ devices to achieve a tunnel barrier height of 0.33 eV for reasons explained by Patent Owner’s expert. Dr. Caroline Ross is a professor at MIT with decades of industry and research experience in MTJ devices and explains why Petitioner’s obviousness theories are baseless.

It is undisputed that Soukup does not describe MTJ devices. As Dr. Ross explains, a POSA working on MTJ devices would not have looked to Soukup. Soukup is non-analogous art unavailable as a matter of law for use in Petitioner’s obviousness combinations. *See infra* §VI.

Even if the Board were to find Soukup sufficiently analogous, Soukup’s teachings would not have motivated the modification to Petitioner’s primary references that Petitioner alleges. At institution, the Board “disagree[d].” DI, 21. Patent Owner is confident the Board will reach a different conclusion on the more fully-developed record which includes Dr. Ross’s testimony and deposition testimony of Petitioner’s expert. **Both** experts agree that (1) Soukup’s devices are

not MTJ devices; (2) Soukup’s electrodes are not magnetic so its devices have no TMR; (3) the dominant current flow mechanism in Soukup for the devices Petitioner relies on were not tunneling;² (4) Soukup used two measurement techniques that produced different alleged “barrier height” values, with one suggesting barrier height increased with oxygen vacancies while the other suggested the “opposite relationship” (DI, 22); and (5) a POSA, like Soukup’s authors, would not have known which of Soukup’s inconsistent results, if any, were correct.

Petitioner’s assertion that a POSA would have been motivated by Soukup—which describes non-magnetic non-tunnelling devices with no TMR—to modify a *magnetic tunnel* junction device to increase its TMR is based on nothing but hindsight. Petitioner cherry-picks Soukup teachings that purportedly support its obviousness theory while ignoring other teachings refuting it. That fails to establish obviousness as a matter of law. *See infra* §VII.D (citing authority).

Petitioner alleges a POSA would have modified the primary reference in both grounds to adopt Soukup’s alleged barrier height value of 0.33 eV. That is the only modified barrier height value Petitioner relies on. But Petitioner’s expert admitted that a POSA would not have known if 0.33 eV was correct rather than a

² The Board questioned this (DI, 21-22) but it is now undisputed. *Infra* §VII.B.

different barrier height value Soukup reports for the same device. Worse yet, Petitioner ignored other evidence (from Soukup’s lead author) explaining that the technique used to produce the 0.33 eV value produces values lower than the real barrier height. Thus, even if Soukup’s “barrier height” values had any relevance to a tunnel barrier height in an MTJ (they do not), Petitioner’s entire case is built on an erroneous 0.33 eV value that does not represent what Soukup’s author called the real barrier height of Soukup’s device.

Despite the problems with Soukup’s measurement technique that generated the erroneous 0.33 eV value, at institution the Board found that Soukup’s other measurement technique (zero-field intercept) produced values within one of the claimed ranges (0.1-0.85 eV) and provides “some support on this record for Petitioner’s asserted modification to modify Bowen’s device to have a barrier height *slightly lower* than 0.9 eV.” DI, 22. Petitioner never relied on the values provided by Soukup’s zero-field intercept method because they fail to meet the narrower range (0.2-0.5 eV) required by over half the challenged claims. As explained *infra* §V.B, Petitioner makes the same single argument against *all* the claims—alleging Soukup would have motivated a POSA to adopt a barrier height of 0.33 eV in the primary references’ MTJ devices. That is the only modified barrier height Petitioner alleges a POSA would have sought to achieve, and it is unsupported by the evidence. Both grounds fail for that additional reason.

* * *

Prior to the inventor’s groundbreaking work, the extremely complex technology in this case was in its infancy and poorly understood even by the world’s leading experts. To the extent a POSA would have had any expectation about the impact on TMR of lowering the barrier height to within either claimed range, a POSA would have expected that it would have undesirably *decreased* TMR—the opposite of what Petitioner alleges. The contemporaneous reaction of those in the field reveals that the inventor achieved surprising and unexpected results that made MTJ devices commercially viable.

The record includes extensive objective evidence of non-obviousness. The inventor, Dr. Yuasa, received more than twenty scientific awards and extensive contemporaneous praise for his work described in the ‘909 Patent. *See infra* §IV. Dr. Yuasa’s work has been cited more than *five thousand* times by others and has appeared in the field’s pre-eminent journals. Petitioner Western Digital’s own employees contemporaneously praised Dr. Yuasa’s work. The assertion now—two decades later—by Western Digital’s attorneys and its paid expert that Dr. Yuasa’s contributions to the art were “obvious” is belied by the *contemporaneous* reaction of those in the field who praised his work as groundbreaking.

In the sections below, Patent Owner explains, with extensive citation to corroborating evidence, why Petitioner’s obviousness theories are baseless. The

record supports only one conclusion—Petitioner fails to carry its burden to prove any challenged claim obvious.

II. MAGNETIC TUNNEL JUNCTION DEVICES

A. Overview

A magnetic tunnel junction (MTJ) device has an insulator, called a tunnel barrier layer, between two ferromagnetic electrodes. EX1017, 1:54-58. Current can flow between the electrodes, through the insulator, via a quantum phenomenon known as “tunneling.” In 1963, Simmons (EX1031) provided a formula to characterize tunneling between electrodes separated by a thin insulating barrier. Simmons’ formula is still used to calculate tunneling barrier heights today. EX1031, 1793.

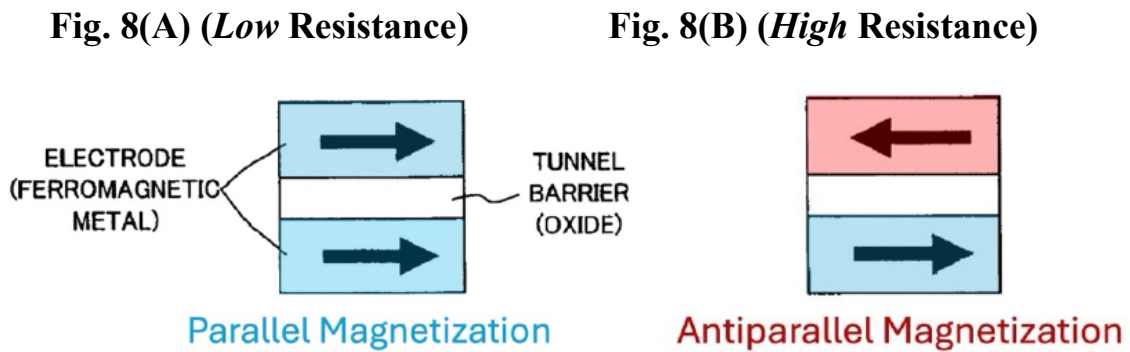
In 1975, Jullierre (EX1033) observed different tunneling conductance and resistance through an Fe-Ge-Co junction when the electrodes’ magnetizations were in parallel versus antiparallel. EX1033, 255-256. MTJs attracted attention for practical applications in the mid-1990s when Miyazaki (EX1034) and Moodera (EX1035) achieved large differences between the parallel and antiparallel resistances through Fe-Al₂O₃-Fe junctions. EX1057, 1-2; EX1055, 2269; EX2053 (Declaration of Caroline Ross, Ph.D., hereinafter “Ross”), ¶¶31-34.

In 2001, Butler (EX1044) and Mathon (EX1046) theorized that the differences between the parallel and antiparallel resistances might be greater in Fe-

MgO-Fe structures. Experimentalists began testing the theory of whether an MgO insulating layer could produce an MTJ device useful for commercial applications which required balancing various below-discussed considerations. Ross, ¶¶41-49.

B. Tunneling Magnetoresistance Ratio (TMR)

An MTJ device's antiparallel resistance R_{ap} is higher than its parallel resistance R_p . MTJ's are "magnetoresistive" because the magnetic state impacts the device's resistance.



"Tunnel magnetoresistance ratio" ("TMR") is the difference between R_{ap} and R_p normalized by R_p as shown by the below-reproduced formula. Petition, 5-6. A higher TMR desirably makes it easier to determine which state the MTJ device is in because it reflects a larger difference between the antiparallel and parallel resistances. EX1017, 5:10-16.

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

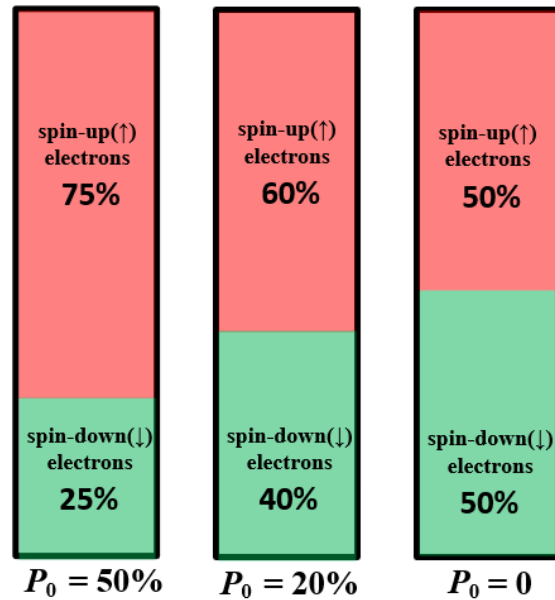
The TMR effect was first observed by Julliere (EX1033). Petition, 5; EX1034, 231; EX2010, 172; EX1057, 42. Julliere taught that TMR could be

explained by the below-discussed “spin polarization” of the magnetic electrodes.

EX1033, 225-226; Ross, ¶¶31-34.

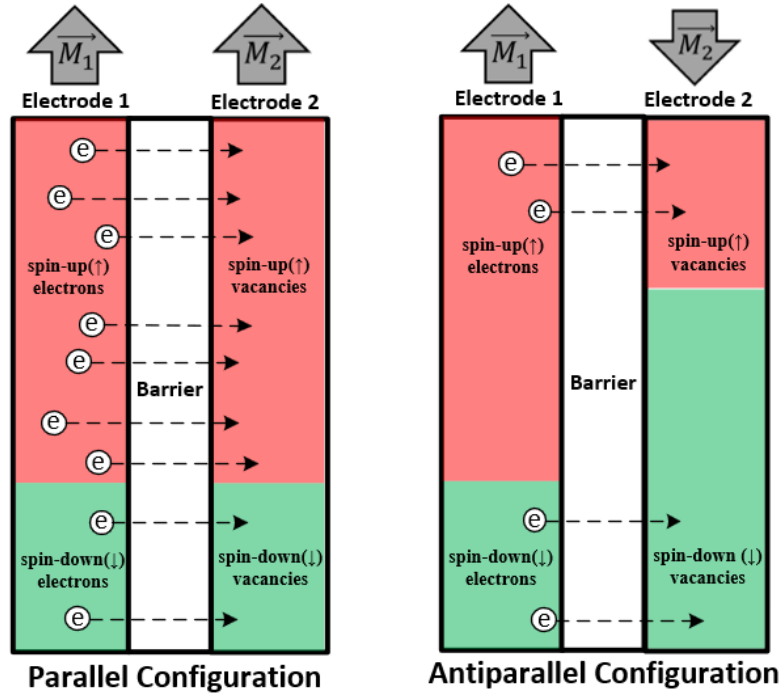
C. Spin-Dependent Tunneling

Magnetic materials have a majority of electrons with spins in a spin-up ($\uparrow$) direction and a minority with spins in a spin-down ($\downarrow$) direction. EX1033, 225-226. An electrode’s spin polarization P_0 equals the difference between the percentage of spin-up ($\uparrow$) and spin-down ($\downarrow$) electrons. Examples are illustrated below, including for a non-magnetic electrode ($P_0=0$). EX1033, 225-226; EX1057, 12; EX2020, 172-173; Ross, ¶35.



Spin-dependent tunneling means tunneling that occurs when an electron in one electrode tunnels through a barrier to fill an electron vacancy of the same spin-state in the other electrode. EX1033, 255-256; EX2010, 172; Ross, ¶36. When a magnetic electrode’s magnetization is flipped, its spin states invert so the majority

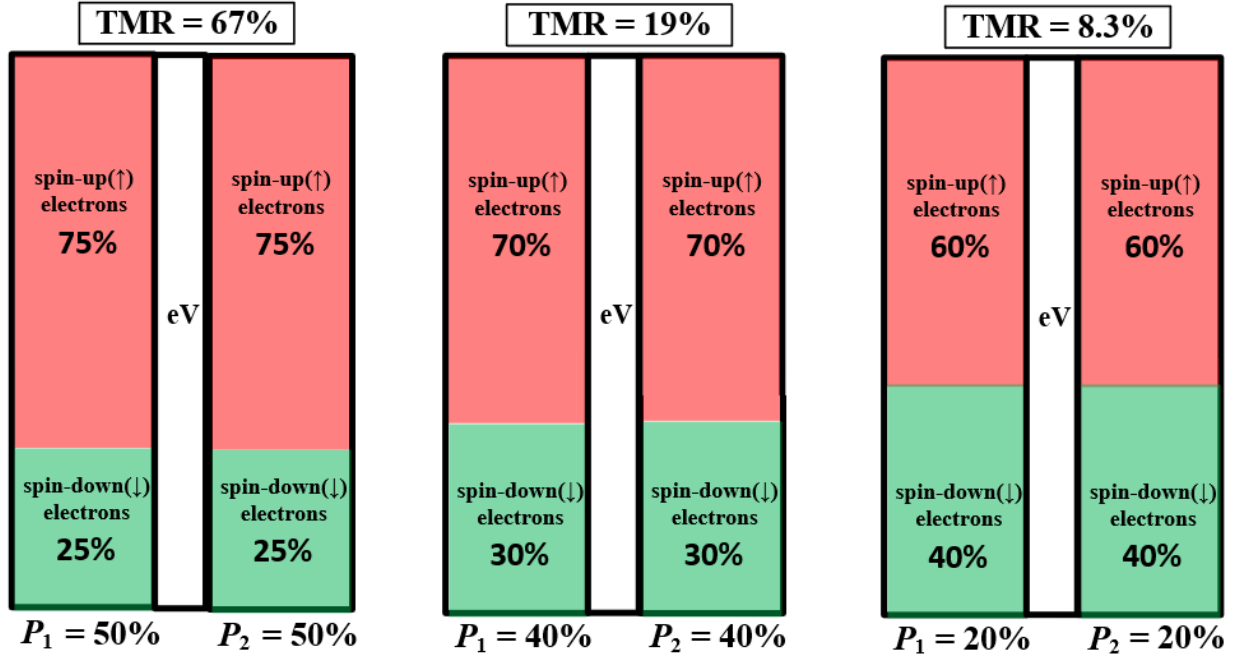
of electrons are spin-down ($\downarrow$) and the minority are spin-up ($\uparrow$). The mismatch in the number of electrons/vacancies aligned in the same spin state when the electrode's magnetizations are anti-parallel reduces tunneling conductance, as illustrated schematically below.³ Ross, ¶¶36-38.



Julliere taught that TMR could be predicted from the spin polarizations P_1 and P_2 of the MTJ's magnetic electrodes as follows, with examples shown conceptually below:

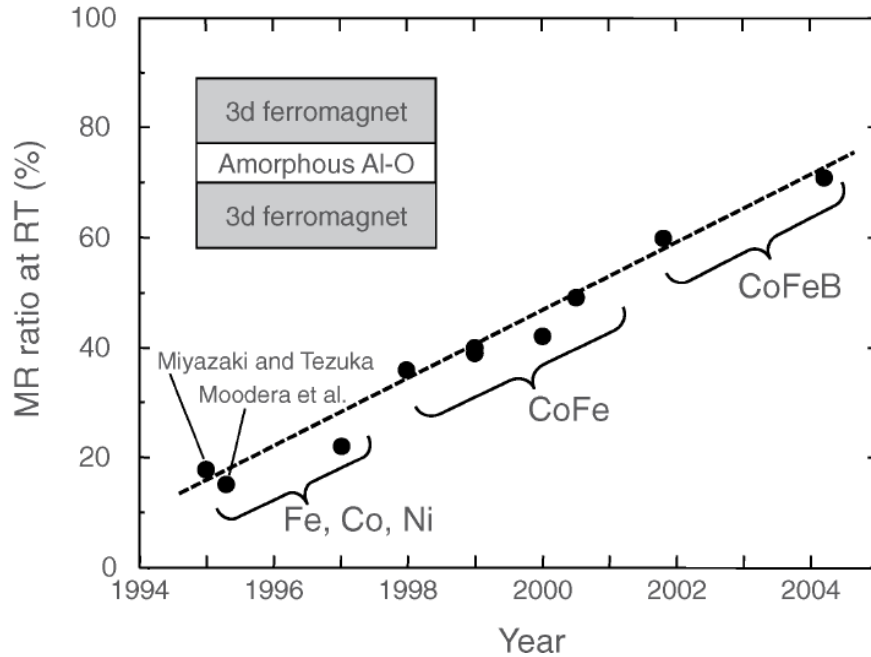
³ At zero voltage bias, electrons tunnel in both directions equally, producing no net current. Applying a voltage across the electrodes biases electron flow in one direction—producing a net current. Ross, ¶37.

$$\text{TMR} = \frac{G_P - G_{AP}}{G_{AP}} = \frac{R_{AP} - R_P}{R_P} = \frac{2P_1P_2}{1 - P_1P_2}$$



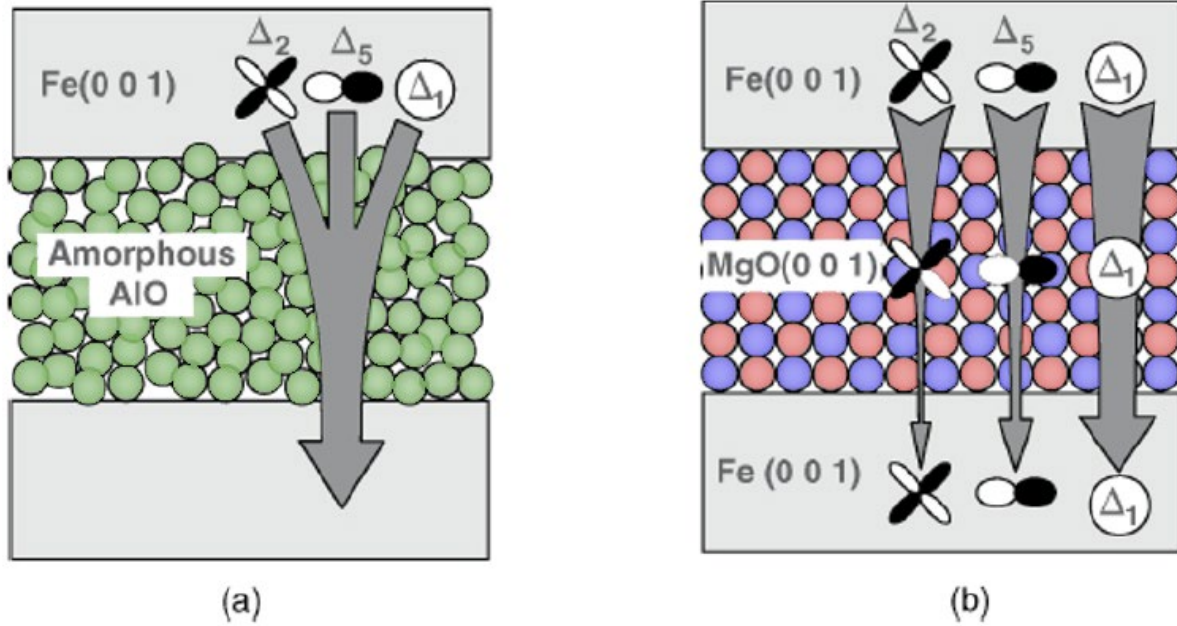
EX1057, 13 (Eq. 1.9); *see also* EX1033, 225-226; EX2010, 172; Ross, ¶39.

Early MTJs predominantly used Al_2O_3 barriers and electrodes with high spin polarizations to leverage spin-dependent tunnelling. EX1057, 43 (Figure 2.18 reproduced below); EX1034, 231; EX1035, 3274; Ross, ¶40.



D. Coherent Tunneling

Theoretical models of crystalline Fe-MgO-Fe junctions predicted higher TMRs than with Al_2O_3 barriers due to symmetry coupling between the crystalline MgO barrier and crystalline iron (Fe) electrodes. EX1044, 1; EX1045, 1. Electron wave functions in crystalline Fe have symmetries referred to as $\Delta 1$, $\Delta 2$ and $\Delta 5$. EX1057, 16; EX1044, 5-6. Crystalline MgO has associated symmetries that couple with the electrode's symmetries, respectively, as shown in Figure 2.19(b) of Dieny (EX1057, 45) reproduced below. Ross, ¶41.



Symmetry coupling (above-right) increases the likelihood that an electron will tunnel from one electrode, through the barrier, to fill a vacancy of the same symmetry-state in the other electrode and is referred to as coherent tunneling enhancement. EX1057, 16-17, 44-45. Amorphous Al_2O_3 barriers (above-left) lack crystallographic symmetry and have no coherent tunneling enhancement. EX1057, 16. Ross, ¶42.

Ferromagnetic electrodes have a relatively large number of majority spin electrons in the Δ_1 state ($\Delta_{1\uparrow}$) and none in the minority spin Δ_1 state ($\Delta_{1\downarrow}$). EX1057, 45; EX1017, 6:1-8, FIG. 1A. Crystalline Fe/MgO/Fe devices were thus predicted to exhibit relatively large Δ_1 -state coherent tunneling enhancement in the parallel configuration, but none in the antiparallel configuration, yielding higher TMR

under the above-discussed spin polarization mechanism. EX1057, 17, 44-45; EX1044, 1; EX1017, 6:1-18; Ross, ¶43.

E. Resistance-Area Product

An MTJ device's resistance-area product (RA) is the device's resistance R per unit area in ohms (Ω) per μm^2 . EX2017, 869; Parkin, 866-867. RA impacts the output voltage across an MTJ at a given current under Ohm's law ($V=IR$). A too-high or too-low RA value would make it difficult for sensing circuitry to distinguish between an MTJ's parallel and antiparallel configurations as discussed *infra* §§III.A-III.B. Ross, ¶¶44, 59-61; EX2013, 75:24-78:10.

F. Tunnel Barrier Height

An MTJ's "tunnel 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 so tunnel barrier height depends on the materials of the electrodes and the barrier. Petition, 8-9; EX1031, 1794-1796, FIGS. 1-2; EX1017, 4:2-8. The upper limit of the tunnel barrier height for an electrode/barrier pairing, what the '909 Patent calls its "ideal" value, can be determined from spectroscopic analysis of the materials. EX1017, 4:66-57 (citing EX1047). The widely-used ideal tunnel barrier height for Fe/MgO/Fe is 3.6 eV. *Id.*, 7:26-31; EX1047, 509; EX1046, 1; EX1045, 2; EX1043, 1; Ross, ¶45.

Fabricated MTJs with MgO layers have barrier heights below the “ideal” because it is difficult to manufacture perfect planar defect-free layers. Ross, ¶46; *see* the table below comparing “ideal” and determined barrier heights (ϕ).

The barrier height of a fabricated MTJ device typically cannot be directly measured but is determined by fitting I - V measurements to a tunneling model using Simmons’ formula. Simmons (EX1031); EX1017, 7:39-8:14 (requiring Simmons’ formula to determine tunnel barrier height); Petition, 9 (acknowledging Simmons’s “widely used” formula); Ross, ¶46.

Reference	Stack	Ideal ϕ	Estimated ϕ
EX1045	Fe/MgO/Fe	3.6 eV	2.5 to 3.6 eV
EX1043	Fe/MgO/Fe-Ni-Au	3.7 eV	3.7 eV (Simmons)
EX1026	Fe/MgO/Fe	Cites EX1047	0.9 eV, 1.1 eV ($I(V)$ temp curves, Simmons)
EX1053	Fe/MgO/FeCo	Not Specified	0.9 eV (Simmons)
EX1047	Fe/MgO/Fe	3.6 eV	1.8 eV (Simmons)
EX2012	CoFe/MgO/CoFe	3.6 eV	1.1 to 1.7 eV (Simmons)

Prior to Dr. Yuasa’s insight to intentionally introduce defects during fabrication to reduce RA (*infra* §III.B), POSAs sought to fabricate MgO MTJs as defect-free as possible to achieve the high TMR values predicted by models for

ideal perfect crystals. EX1044 (Butler); EX1046 (Mathon); Ross, ¶¶47-49 (citing EX1047, 509-511; EX1051, 2; EX1045, 1; EX1053, 8042-8043).

G. Storage Device Applications

A magnetoresistive random access memory (“MRAM”) is composed of cells, each including an MTJ device storing a bit of data, with the parallel and antiparallel states encoding a binary “0” or “1,” respectively. EX1017, 1:37-2:39, 2:4-7, 2:21-25. Because an MTJ’s R_{ap} is higher than its R_p , whether the cell stores a “0” or “1” is determined by whether the cell’s resistive load is relatively high or low. *Id.*, 1:60-2:9; 2:18-24. An MTJ device can alternatively be used as a read-out sensor for a magnetic disk drive storing data on a disk using different magnetization states to encode binary “0s” and “1s.” EX1027 (“Nagahama”), [0082]; EX2005 (“Zhu”), 41, Fig. 12.

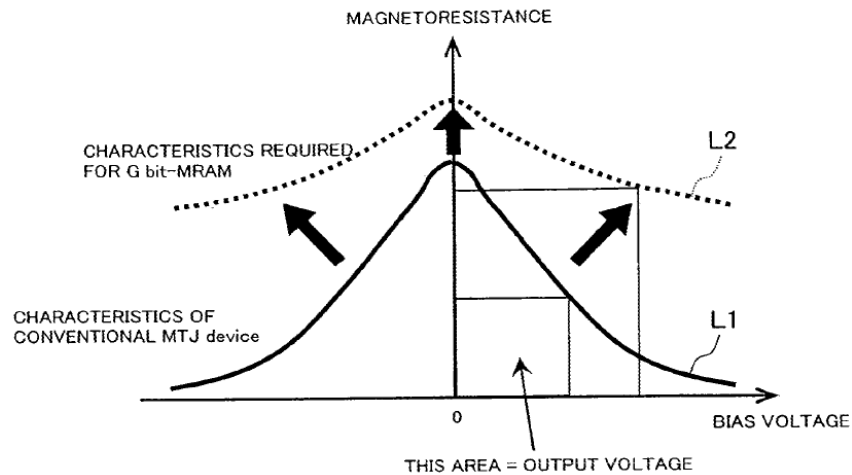
III. ’909 PATENT

A. Overview

Dr. Yuasa recognized that while “MRAMs with capacities on the order of 64 Mbits” could be achieved using then-current technologies, “the characteristics of the MTJ device [] needs to be improved if higher levels of integration are to be achieved.” EX1017, 2:45-67. This required smaller MRAM cell sizes which would make it more challenging to accurately detect the signal indicating whether the MTJ was in its parallel or antiparallel state given the circuit’s noise. *Id.*

As shown by line L1 in Fig. 10 below, conventional MTJs had a “small” TMR that “drastically decrease[s] upon application of bias voltage” which rendered those MTJ devices unsuitable for MRAM devices. *Id.*, 2:52-61. L2 shows the TMR characteristics needed to support a Gigabit MRAM. EX1017, FIG. 10; Ross, ¶¶50-52.

FIG. 10



B. Invention

Dr. Yuasa recognized that to make an MTJ suitable for use in high capacity MRAM, its *RA* (*supra* §II.E) should be within a certain range to allow the MTJ device’s state (parallel or antiparallel) to be accurately detected by sensing circuitry. Ross, ¶¶44, 56, 59; ‘909 Patent’s FIG. 9(B).

If the MTJ’s *RA* was too high, current through the MTJ would be small in both the parallel and antiparallel states. Ross, ¶59. Even if the TMR were high,

sensing circuitry would have difficulty distinguishing between those two small current values given signal variation from other circuit components. *Id.* Increasing circuit density exacerbated the problem. *Id.*

If RA was too low, resistance of other circuit components (*e.g.*, metallization) could become comparable to the MTJ's resistance, making the difference between the parallel and antiparallel resistances small relative to the rest of the circuit and thus make it difficult to accurately detect the MTJ's state. *Id.* Low RA values could also favor non-tunneling current through the MTJ which would be independent of its magnetic state and thus decrease TMR. *Id.*

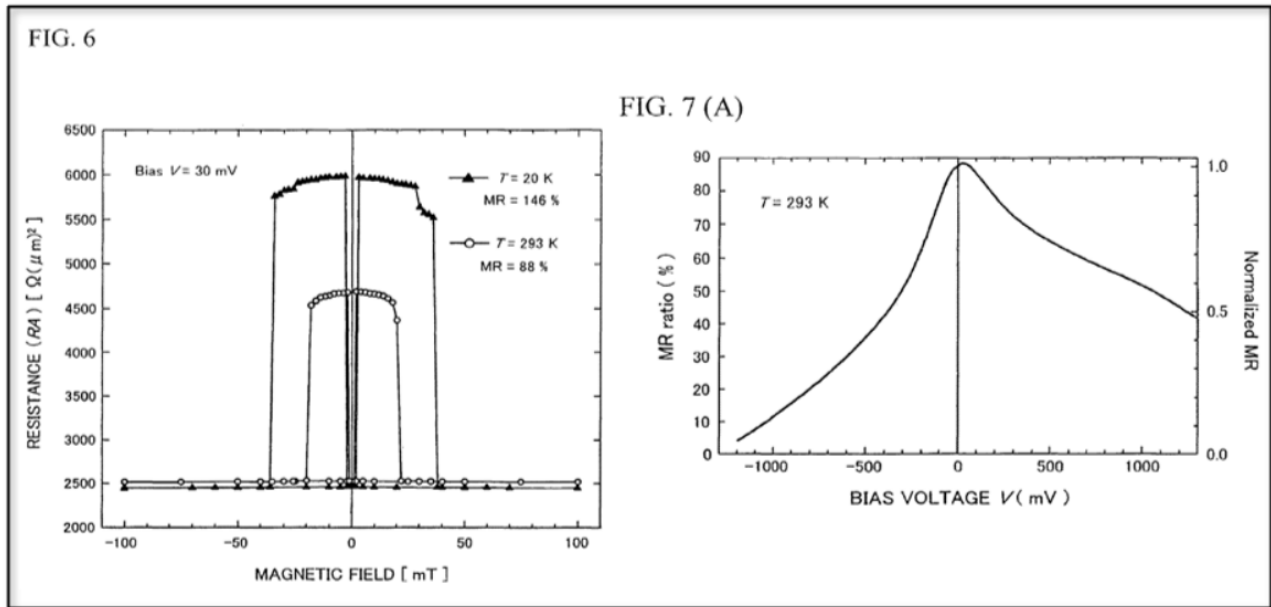
Dr. Yuasa also recognized that Al_2O_3 -based MTJs exhibited peak TMR values that were too low and decayed too rapidly for use in large-capacity MRAM, and that Jullier's equation predicted limits on TMR achievable from electrode spin polarization alone that would prevent realization of high-capacity MRAM. EX1017, 2:45-67, 5:25-38. Ross, ¶¶50-53.

Dr. Yuasa understood the "possibility that a very high MR ratio can be obtained in a coherent spin polarized tunneling" between ferromagnetic electrodes and crystalline or polycrystalline MgO barrier layers. EX1017, 6:7-18; EX2017, 868-869. Butler's theory predicted high TMR based on a defect-free crystalline MgO layer. EX1044, 1-4. But Dr. Yuasa recognized that the tunnel barrier height for defect-free crystalline MgO was too high for MRAM applications because the

MTJ's *RA* would be too high. EX1017, 6:12-18, 4:66-5:7, 7:26-27; EX2017, 869⁴ (“the barrier height of an ideal MgO tunnel barrier height (3.7 eV) is too high for the device [MRAM] applications.”); Ross, ¶¶54-56.

Dr. Yuasa had the insight to lower the tunnel barrier height by introducing oxygen vacancy defects into the MgO crystal to lower the bottom of the conduction band of the MgO barrier layer. EX1017, 3:59-61, 7:19-37, 9:4-10 (describing techniques for introducing oxygen vacancy defects), 7:38-8:14 (tunnel barrier height is determined using Simmon's formula); EX2017, 869. The expectation was that lowering the barrier height would decrease TMR like it was known to do for Al₂O₃-based MTJs. EX2017, 869. Yet, Dr. Yuasa surprisingly achieved “the highest MR ratios that [had] so far been obtained at room temperature” with small bias voltage dependency and a “resistance-area (RA) product” “suitable for MRAM.” EX1017, 8:19-30, 31-46; FIG. 6 (below left showing TMR and *RA* values), FIG. 7(A) (below-right showing TMR and slow decay); EX2017, 869; EX2037, L1036; Ross, ¶¶56-58.

⁴ EX2017 is Dr. Yuasa's 2004 Nature Materials paper describing the MTJ device claimed in the '909 Patent. Ross, ¶¶62, 152-153.



Dr. Yuasa's discovery that an MTJ device with an MgO barrier layer could be realized with RA characteristics and TMR suitable for commercial applications⁵ by lowering the tunnel barrier height via introduction of oxygen vacancy defects into the MgO lattice was a ground-breaking advance, as evidenced by the widespread acclaim Dr. Yuasa received. *Infra* §IV.A; Ross, ¶¶59-62.

IV. OBJECTIVE EVIDENCE OF NONOBVIOUSNESS

Secondary consideration evidence is always highly relevant to an obviousness analysis. *Apple v. Samsung*, 839 F.3d 1034, 1052-53 (Fed. Cir. 2016)

⁵ Dr. Yuasa recognized that his invention had commercial applications beyond MRAM, including in hard disk drives which have widely adopted his technology. EX2021, 3 (citing EX2015, EX2016, EX2017).

(en banc) (“evidence of secondary considerations may often be the most probative and cogent evidence in the record. It may often establish that an invention appearing to have been obvious in light of the prior art was not. It is to be considered as part of all the evidence, not just when the decision maker remains in doubt after reviewing the art.”); *KSR v. Teleflex*, 550 U.S. 398, 406 (2007).

Dr. Yuasa is a widely-recognized luminary in the MTJ device field because of his contributions described in the ’909 Patent. His family of related patents cover innovations that made MTJ devices commercially viable. Dr. Yuasa’s foundational papers on the work described in the ’909 Patent has been cited over **5,000 times**. EX2008, EX2009. For his pioneering contributions, Dr. Yuasa has been awarded or co-awarded more than ***twenty (20) prestigious scientific awards or prizes***.

Petitioner ignores secondary considerations entirely despite evidence of industry praise, failure of others, and long felt but unmet need appearing in the Petition’s own exhibits and statements from Petitioner’s own employees, as well as in the district court complaint served on Petitioner before this Petition was filed. *See* EX1063 (Complaint), ¶¶12, 21-26.

A. Industry Praise

Shortly after filing the two Japanese patent applications to which the ’909 Patent claims priority, Dr. Yuasa disclosed the ’909 Patent’s embodiments in the

Japanese Journal of Applied Physics (“Yuasa-JJAP,” EX2016), in Nature Materials (“Yuasa-Nature,” EX2017), and in Applied Physics Letters (“Yuasa-APL,” EX2015), collectively the “Yuasa Papers.” The Yuasa Papers appear in prominent peer-reviewed journals. Ross, ¶152; EX2013, 24:4-23, 191:20-22 (Petitioner’s expert admitting same).

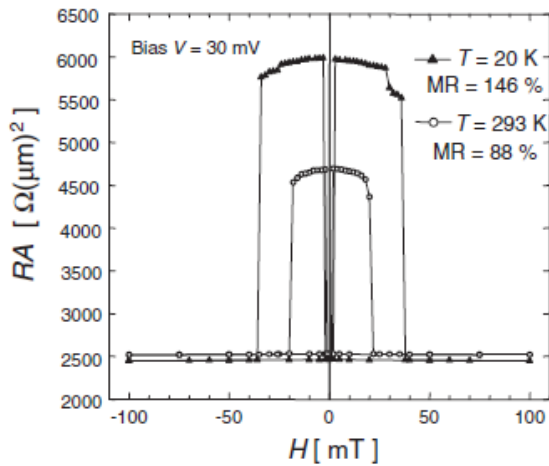
Dr. Yuasa disclosed the ’909 Patent’s *claimed* device in Yuasa-Nature.

Ross, ¶153. Yuasa-Nature disclosed:

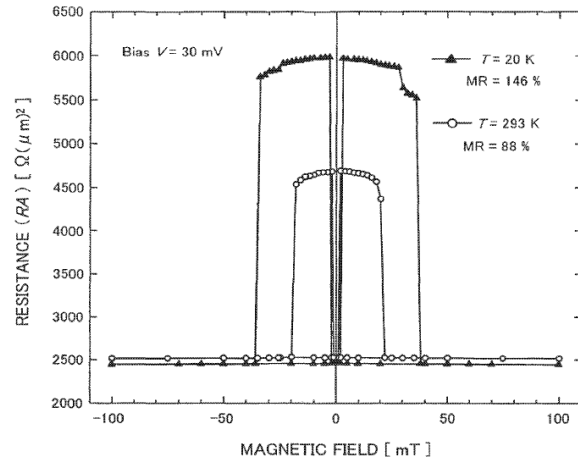
- Limitations 1[pre], 9[pre], 15[pre] by disclosing “MTJs” (EX2017, 868-869);
- Limitations 1[a]-1[b], [9a]-9[b] and 15[a]-15[c] by disclosing “Fe(001)/MgO(001)/Fe(001) MTJs” (EX2017, 868-869);
- Limitation 1[c] by disclosing “Oxygen vacancies in MgO” (EX2017, 869); and
- Limitations 9[c], 15[b] and claims 5-6 by disclosing “a barrier height ϕ of 0.39 eV” and “ $\phi = 0.37\text{--}0.40$ eV” (EX2017, 869).

Yuasa-Nature has been cited more than **4,100** times. EX2008. The ’909 Patent’s figures showing the *RA* and TMR characteristics of Dr. Yuasa’s ground-breaking MTJs appear in Yuasa-JJAP and Yuasa-Nature as shown below.

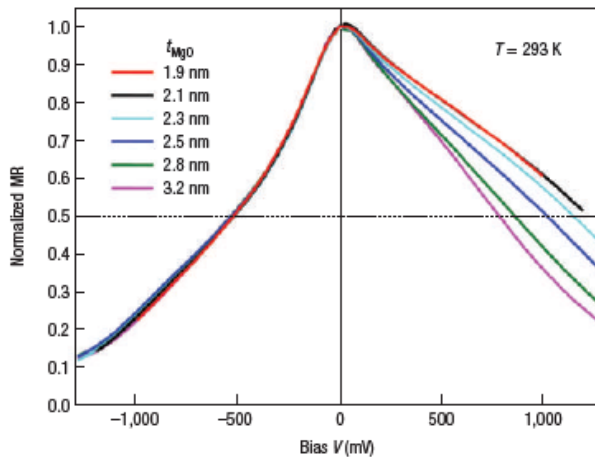
Yuasa-JJAP Fig. 3



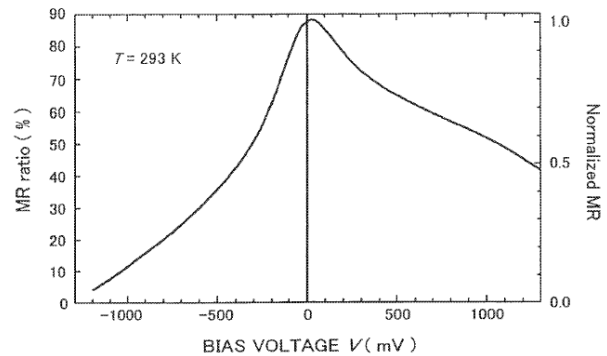
'909 Patent Fig. 6



Yuasa-Nature Fig. 3a



'909 Patent Fig. 7(A)



Dr. Yuasa's disclosure of the claimed inventions drew contemporaneous praise, including from Petitioner's employees. EX2005, 38 and EX2022, 107 (both citing Yuasa-Nature). A 2005 *Advances in Physics* paper characterized Dr. Yuasa's devices as having "unprecedentedly large TMR ratios" using "MgO barriers" and "pure Fe electrodes." EX2019, 591-592. Nobel laureate Albert Fert—a co-author

of Ground 1's primary reference Bowen (EX1026)—called Dr. Yuasa's Nature paper an "important breakthrough" and "the most important step [in] the transition from MTJ with amorphous tunnel barrier (alumina) to single-crystal MTJ and especially MTJ with MgO barrier." EX2020, 8 (citing Yuasa-Nature). This "breakthrough" is seen in the figure below, from a textbook (EX1057) chapter Petitioner cites,⁶ showing a greater than 250% increase in TMR. Ross, ¶¶154-155.

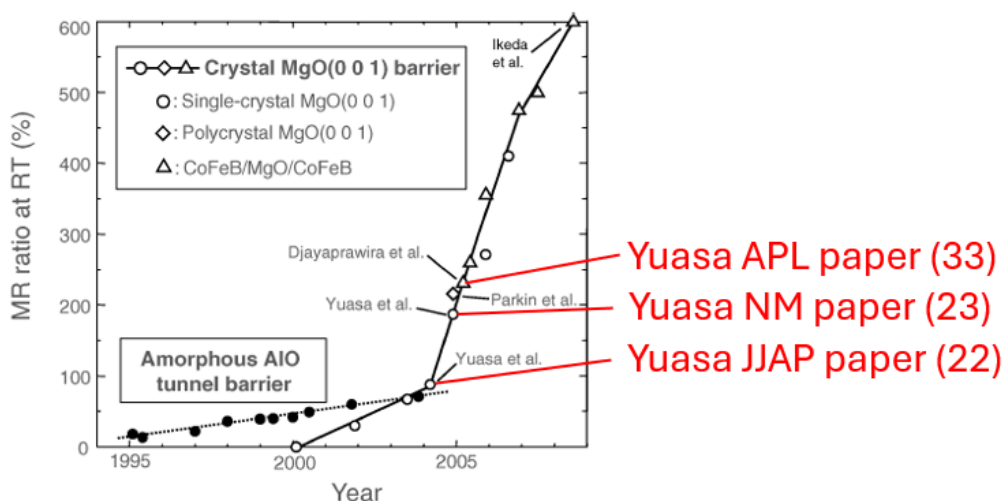


Figure 2.21 History of improvement in MR ratio at RT for MTJs with amorphous AlO barrier (solid circles) or crystalline MgO(001) barrier (open symbols). Data are shown for work by Yuasa et al. (22,23), Parkin et al. (24) Djayaprawira et al. (33), and Ikeda et al. (36).

EX1057, Figure 2.21 (annotated).

Dr. Yuasa's MgO-based MTJ devices described in the Yuasa Papers were the first to achieve high TMR values as predicted by theoretical models, marking

⁶ Dr. Yuasa authored the chapter but the data is undisputed (EX1057, 45-46) and Petitioner cites this chapter repeatedly. Petition, 6, 10-11 and 13.

the inflection point for MgO-based MTJs (shown above), and received wide-spread praise. EX2005, 38 (Petitioner’s employee Chando Park hailed Yuasa-Nature as one of “two independent experimental investigations show[ing] greater than 180% and 220% TMR ratios at room temperature” spawning a “surge in research [that] quickly followed”); EX2019, 591-592, EX2020, 8; EX2022, 107; EX1063, ¶22. Because Yuasa-Nature disclosed the claimed MTJs that resulted in the MgO-based MTJs with “unprecedentedly large TMRs” and were the “important breakthrough,” there is a direct nexus between the praise and the claimed invention. Ross, ¶156.

Petitioner’s employee, Zheng Gao, credited Dr. Yuasa as being the first to demonstrate that with coherent tunneling, the “effective barrier height can also be smaller [], which makes a TMR sensor with *low resistance and high TMR possible*.” EX2022, 107 (citing Yuasa-Nature). Dr. Yuasa’s development of the first low-resistance high-TMR MTJ sparked further research, including his own (EX2021), into developing MTJs with further reductions in MTJ resistances down to the “*RA* range [] desired for [the hard disk drive] read head application.” EX2022, 107 (citing EX2017, EX2021). Because Yuasa-Nature disclosed the claimed MgO-based MTJs that demonstrated that the tunnel barrier height could be small and made “a TMR sensor with low resistance and high TMR possible,” the praise has a direct nexus to the claimed invention. Ross, ¶157.

For his groundbreaking work, Dr. Yuasa has been awarded or co-awarded numerous prizes. For example, Dr. Yuasa was awarded the Tsukuba Prize in 2009, including a monetary award of 5 million yen, for his development of the “***first successful*** creation of a three-layer ‘magnetic tunnel junction element (MTJ element) ***in the world***, composed of iron and MgO (magnesium oxide), paving the way for mass production.” EX2033, 2; EX2032, 1; Ross, ¶¶158-160.

In 2016, Dr. Yuasa won the “Science and Technology Prize” for his “new type of tunnel magnetoresistance element ... using crystalline magnesium oxide (MgO) as the tunnel insulating film,” for which “***a giant tunnel magnetoresistance effect of approximately 200% at room temperature was realized for the first time in the world***” and resulted in “magnetic sensor elements using MgO tunnel magnetoresistance elements [being] put to practical use and [that] are now used in all hard disk storage devices (HDDs) currently being manufactured, resulting in a dramatic increase in HDD capacity, lower prices, and reduced power consumption.” EX2029, 2; Ross, ¶159.

In 2022, Dr. Yuasa was awarded the “Japan Society of Applied Physics Achievement Award,” for his “pioneering work on magnetic tunnel junctions (MTJs) with magnesium oxide (MgO) tunnel barriers” and his development of “technologies to ***reduce the resistivity of elements***, which is indispensable when

increasing the density of HDDs and MRAMs.” EX2024, 2-3. These awards have a direct nexus to the MTJs claimed in the ’909 Patent. Ross, ¶¶158-162.

B. Long-felt Need/Failure of Others

MTJ devices fall into a larger field—called spin-based electronics or spintronics—spawned by discovery of the giant magnetoresistance (GMR) effect in metallic structures in 1988. EX2020, vii, 3; EX1057, 1-2. GMR had been used in magnetoresistive heads in hard disk drives from 1998-2004. EX1057, 8-9.

Another commercial application for spintronics was MRAM, which promised a non-volatile alternative to DRAM. EX1039, 2814; EX1017, 1:44-50. MRAM began to be considered seriously in 1995 after an MTJ with a 10% TMR was achieved. EX1057, 1-2 (citing EX1034, EX1035). In 1999, MTJ devices were considered one of the “most viable” MRAM technologies. EX1039, 2819. But commercialization was not feasible in 1999 because TMRs were too low and manufacturing techniques were incompatible with large scale manufacturing. EX2038, 6-7; EX2055, 8-9; Ross, ¶163.

Researchers tried but failed to solve the problem of obtaining a high TMR. From 1995-2000, extensive experimental effort was made on MTJs with aluminum oxide tunnel barriers, but the resulting TMRs were only 10-70 %, “lower than those needed for many applications of spintronic devices.” EX1057, 9; EX2055, 5-9; Ross, ¶164.

In 2001, theorists Butler (EX1044) and Mathon (EX1046) speculated that higher TMRs could be obtained using crystalline MgO tunnel barriers. EX1057, 16. These theoretical predictions “led to numerous experimental studies to explore the possibility of high TMR in epitaxial (100) oriented Fe/MgO/Fe tunnel junctions.” EX2055, 10-11. Early attempts failed to produce large TMRs. *Id.*, 10-16 (citing EX1047, EX1052, EX1053, EX1026 as failed attempts). Ground 1’s Bowen was one such failure. Bowen’s MTJs with an MgO tunnel barrier produced TMRs of only 27%—lower than had been achieved with conventional AlO tunnel barriers. EX2055, 12; EX1057, 45; EX2020, 8 (all citing Bowen as a failed attempt); Ross, ¶165.

As noted by Petitioner’s employee, Zheng Gao, Dr. Yuasa led the way to an MTJ usable for the hard disk drive “read head application” when he discovered that the barrier height could “be smaller,” making “a TMR sensor with *low resistance and high TMR possible*.” EX2022, 107 (citing EX2017 (Yuasa-Nature) and EX2021); Ross, ¶166. Dr. Yuasa solved the long-felt need for an MTJ device with the low resistance and high TMR needed for commercial applications with his work described in the ’909 Patent. *Id.* He achieved an MgO-based MTJ with a TMR of 88% at a room temperature—“the highest MR ratios that have so far been obtained at room temperature.” EX1017, 8:15-21; EX2019, 591-592; EX2022, 107; EX1057, 45-46.

Dr. Yuasa also recognized that by introducing oxygen vacancy defects into the MgO barrier the tunnel barrier height could be lowered from 3.6 eV (for an ideal MgO crystal) to a range of 0.10-0.85 eV, and more specifically to 0.2-0.5 eV, thus providing a “resistance-area (RA) product of the MTJ device [] suitable for MRAM.” *Id.*, 8:15-30, 7:19-38, 9:4-10; Ross, ¶167. Despite an expected reduction in TMR due to lowering the barrier height, Dr. Yuasa surprisingly achieved the highest TMR to date and created the first “TMR sensor with low resistance and high TMR” needed for HDD and MRAM applications. *Id.*; EX2022, 107; EX2017, 867-869.

V. BOTH GROUNDS FAIL BECAUSE NO EVIDENCE SUPPORTS PETITIONER’S ALLEGED REASON WHY A POSA WOULD HAVE MODIFIED EITHER PRIMARY REFERENCE

Ground 1 alleges that claims 5-6 and 9-20 (“Challenged Claims”) would have been obvious over Bowen and Soukup. Petition, 33-37 and 42-46.⁷ Ground 2 alleges that the Challenged Claims would have been obvious over Nagahama and Soukup. Petition, 57-59 and 62-67.

⁷ Ground 1 relied on Bowen alone, or in combination with Sunai or Parkin, only for now-disclaimed claims 1-4 and 7-8.

Every Challenged Claim requires a tunnel barrier layer comprising magnesium oxide (MgO) and recites a barrier height of 0.1-0.85 eV (claims 5, 9-11 and 13-14) or 0.2-0.5 eV (claims 6, 12 and 15-20).

Petitioner admits Bowen’s tunnel barrier height is too large to meet either claimed range and identifies no barrier height value for Nagahama. Petition, 33-34 and 57-58. Petitioner alleges a POSA “would have been motivated to apply Soukup’s teachings about an MgO thin-film barrier with a ‘barrier height’ of ‘about ***0.33eV***’ to Bowen’s MgO barrier” (*id.*, 33-34) and “to Nagahama’s MgO barrier” (*id.*, 57-58).

Soukup’s alleged barrier height of ***0.33 eV is the only barrier height value*** Petitioner alleges a POSA had reason to adopt in Bowen or Nagahama.⁸ Petitioner makes this argument for claim 5—reciting a barrier height range of 0.1-0.85 eV (Petition, 33-36 and 57-59)—and relies on that showing for every Challenged Claim, including those reciting the narrower range of 0.2-0.5 eV. *See* Ground 1: *id.*, 37 (claim 6), 43 (limitation 9[c]), 44 (limitation 15[b]); *see* Ground 2: *id.*, 59 (claim 6), 63 (limitation 9[c]), 65 (limitation 15[b]).

⁸ While Soukup’s 0.33 eV value is not a tunnel barrier height value that could meet any Challenged Claim because it is not determined using Simmon’s formula, both grounds fail for the reasons discussed in this §V even if it were.

Petitioner’s assertion that Soukup would have motivated a POSA 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.

A. Petitioner Needed to Establish Some Supportable Reason Why Soukup Would Have Motivated a POSA to Modify Bowen’s or Nagahama’s MTJ

To demonstrate any claim obvious, Petitioner needed to establish some supportable *reason why* a POSA “would have selected and combined [the] prior art elements” in a manner “yield[ing] the claimed invention.” *Unigene Labs. v. Apotex*, 655 F.3d 1352, 1360 (Fed. Cir. 2011); *see also KSR*, 550 U.S. at 418 (same); *TQ Delta v. Cisco Sys.*, 942 F.3d 1352, 1359 (Fed. Cir. 2019) (reversing the Board’s obviousness determination because the Board “fails to identify any actual *reason why* a skilled artisan would have combined the elements in the manner claimed.”) (internal citations omitted)).

B. Petitioner’s Sole Alleged Reason For Lowering the Barrier Height in Bowen and Nagahama – to Increase TMR – is Unsupported By Any Evidence

Petitioner alleges a POSA “would have been motivated to apply Soukup’s . . . ‘barrier height’ of ‘about 0.33 eV’ to Bowen’s MgO barrier” because “lowering the resistance (barrier height) for parallel electrons (R_p) would *improve TMR*” which was desirable because “*increasing TMR* [would] enable better performing MRAM.” *Id.*, 34; *see also id.*, 35 (alleging a POSA “looking to *increase TMR* of

an MgO barrier would have [] explore[d] lower barrier heights to facilitate tunneling of *parallel* electrons”) and 36 (alleging a POSA “would have been motivated to . . . *improve TMR by lowering the barrier height* as taught by Soukup.”). Petitioner offers the same alleged motivation for adopting Soukup’s alleged barrier height of 0.33 eV in Nagahama – to lower the barrier height to “improve TMR.” Petition, 57-59.

Increasing TMR is the *only* reason Petitioner alleged for why a POSA would have lowered the barrier height in Bowen or Nagahama.⁹ Petition, 33-36 and 57-59. Patent Owner does not dispute that a high TMR was among the goals for an MTJ device. But no evidence supports Petitioner’s assertion that a POSA would have expected that lowering the barrier height in Bowen or Nagahama would have increased TMR. That is fatal to both grounds.

1. Barrier Height and R_p are Different

Contrary to Petitioner’s parentheticals equating them (Petition, 34 and 58), barrier height and R_p are different. Ross, ¶¶63-65. As Petitioner elsewhere admits, tunnel barrier height is “the difference between the bottom of the conduction band

⁹ Petitioner’s allegation that the *way* a POSA would have lowered barrier height was by increasing oxygen vacancy defects offers no reason why a POSA would have sought to lower the barrier height in the first place. Petition, 34-35 and 57-59.

of the tunnel barrier layer and the Fermi level of electrons in the conductor”

measured in eV. Petition, 8-9. It is not a resistance measured in Ohms. Ross, ¶65.

2. Petitioner’s Allegation that Lowering the Barrier Height Would Lower R_p Fails to Establish that this Would Increase TMR

Petitioner alleges that “[a]ccording to the [below] equation for TMR, lowering the resistance (barrier height) *for parallel electrons (R_p)* would improve TMR.” Petition, 34; *see also id.*, 57-58 (citing Ground 1’s showing) and 5-6 (providing the equation below). Petitioner is wrong. Ross, ¶66.

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

As conceded by Petitioner’s expert, lowering the barrier height would not increase TMR unless it *lowered R_p proportionally greater than R_{ap}* . EX2013, 118:1-119:14; Ross, ¶66. Petitioner never even alleged that this was so. The Board preliminarily found that Petitioner’s expert testified in EX1024, ¶169 that lowering the barrier height would have lowered R_p compared to R_{ap} . DI, 17. But as Petitioner’s expert admitted he did not say that in ¶169. EX2013, 133:11-20; Ross, ¶67.

3. Petitioner’s Expert Admitted that a POSA Would Not Have Known Whether Lowering the Barrier Height Would Have Increased, Decreased or Had No Effect on TMR

Petitioner’s expert, Dr. Bokor, admitted repeatedly 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. EX2013, 47:18-49:11, 50:7-51:22, 52:6-20, 52:21-54:3, 54:4-57:6, 57:7-58:16, 79:15-80:24, 125:14-127:19, 129:18-130:3, 154:1-19. While he often said a POSA would have expected that changing the barrier height would have had *some* impact on TMR (albeit one a POSA could not have predicted), Dr. Bokor ultimately conceded a POSA might have also expected it to have *no* impact on TMR. EX2014, 38:8-40:15, 214:18-216:19.

Dr. Bokor’s admission that a POSA would not have known whether lowering the barrier height of an MgO layer would have increased TMR is stunning given that he signed a declaration saying the opposite – “[o]ne of skill would have been motivated ... *to improve TMR by lowering the barrier height.*” Bokor-Declaration, ¶176. Dr. Bokor’s testimony is not credible.

4. Petitioner’s Expert Admitted He Cited No Prior Art Reference Teaching That Lowering Barrier Height Would Have Increased TMR

Petitioner’s assertion that lowering barrier height “would improve TMR” cites a string of references and Dr. Bokor’s ¶¶169 and 276. Petition, 34 (Ground 1)

and 57-58 (Ground 2). Petitioner cited these same references to explain TMR before discussing barrier height¹⁰ and Dr. Bokor admitted he cited these references only to explain TMR. EX2013, 136:12-143:105. Dr. Bokor's cited paragraphs also cited EX1057, 13 which never mentions barrier height.

Dr. Bokor admitted that none of the cited references, and neither cited paragraph from his declaration, says anything about the impact of lowering barrier height on R_{ap} or says that lowering barrier height would increase TMR. EX2013, 114:2-115:6, 115:7-119:14, 119:15-125:13, 126:7-127:19, 132:10-134:17, 136:12-143:5, 149:8-23, 150:12-154:1-19, 186:22-190:5; EX2014, 43:9-45:9, 47:5-53:21.

In alleging a reasonable expectation of success, Petitioner says a POSA "would have been motivated to achieve Soukup's barrier height in an MgO MTJ to improve tunneling and hence TMR." Petition, 35. As Dr. Bokor confirmed at deposition, Petitioner cited Soukup only to teach an alleged barrier height of 0.33 eV, not to teach that lowering barrier height would increase TMR. EX2013, 188:2-188:19; EX2014, 219:24-223:8. Soukup describes *non-magnetic* Au-MgO-Au devices. Soukup, 3230, 3232; *Infra* §§VI.A.2-VI.B.2, VII.A-VII.B. Soukup's devices had no TMR because they had no parallel and antiparallel states. Ross, ¶128; EX2014, 219:24-223:8. The TMR effect had not even been discovered when Soukup published his study. *Supra* §II.A; *infra* §VI.A.2.

¹⁰ Petition 6.

Petitioner's obviousness allegations for the claimed barrier heights make a single reference to "compar[ing]" an MTJ's parallel and antiparallel states, alleging that "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." Petition, 34 (citing EX1044 ("Butler"), EX1046 ("Mathon") and EX1024, ¶170) and 58 (cross-referencing Ground 1). Butler and Mathon's theory of high TMR "*due to improved symmetry matching*" related to coherent tunneling enhancement (*supra* §II.D) and had nothing to do with barrier height. Ross, ¶¶83-85, 92-96, 98-102. Dr. Bokor admitted that neither Butler nor Mathon taught that lowering barrier height would increase TMR and that a POSA would *not* have reached that conclusion from Butler or Mathon. EX2013, 72:8-25, 104:14-17, 117:20-25, 123:5-23, 129:11-130:3.

Leaving no doubt, Dr. Bokor admitted that *no prior art teaching* he was aware of taught that lowering barrier height would increase TMR, and that he never testified that a POSA would have expected that lowering barrier height would have increased TMR. EX2013, 103:21-104:25, 129:18-130:3, 133:11-134:17, 149:8-23, 150:12-154:11, 154:11-19 (Q: "it is your opinion that a POSA did not actually know that reducing the barrier height would increase TMR? A: I do not have evidence for that. Q: . . . You do not have evidence that a POSA would

have known that reducing barrier height would increase TMR; right? A: That's what I've been testifying.").

5. The Only Prior Art Teaching of a Relationship Between Barrier Height and TMR Teaches the Opposite of What Petitioner Alleges

At institution, the Board suggested that "other evidence of record" "appears" to support that lowering barrier height would increase TMR because Moodera (EX1035) teaches a "strong influence of tunnel barrier height on $\Delta R/R$ [TMR]." DI, 17-18. But Moodera teaches the opposite of what Petitioner alleges.

Moodera reflects the teaching in the art that Yuasa-Nature noted—the expectation was that lowering barrier height would have undesirably *decreased* TMR which taught away from what Dr. Yuasa did and from Petitioner's combinations. EX1035, 3276; EX1038, 4728; EX2017, 869; Ross, ¶¶68-80; EX2013, 142:18-143:5, 146:7-148:9 (Dr. Bokor admitted Moodera does not say that lowering the barrier height would increase TMR); *supra* §III.B.

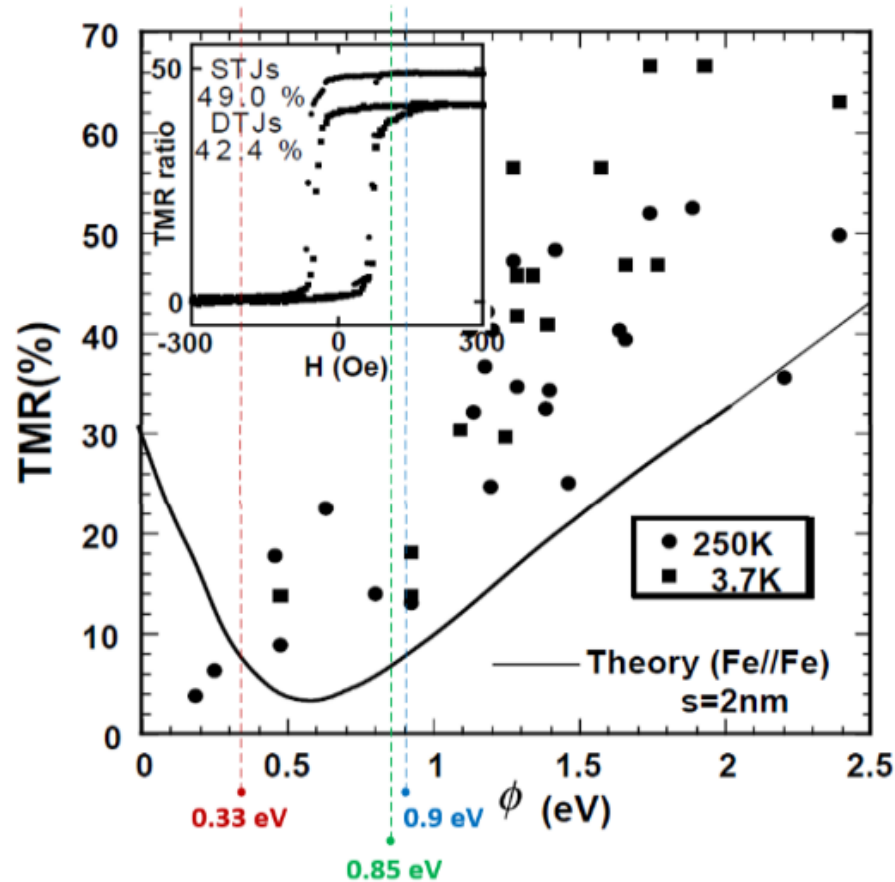
Moodera is a 1995 paper describing CoFe/*Al*₂O₃/Co junctions. Moodera, Abstract; Ross, ¶¶74-75. The disclosure the Board noted discusses a 1989 theory by Slonczewski (EX2041) to describe tunneling through a rectangular barrier. *id.*, 3273; EX2041, 6995; Ross, ¶¶70-73. Moodera explains that lowering the barrier height *decreased* TMR. Moodera, 3276 ("The Slonczewski theory [13] predicts a decrease in spin polarization [which decreases TMR] with barrier height."); Ross,

¶74. Moodera predicted the same relationship for MgO barrier layers. EX1038, 4726 (“MgO, with its smaller barrier height, is effective more than the Al₂O₃ barrier. This can increase the tunneling probability for the minority spins. This spin polarization of the tunneling current can then be expected to decrease [lower TMR], as discussed in Slonczewski’s theory.”); Ross, ¶76.

In 2000, Saito (EX2037) measured TMR for devices of different barrier heights and plotted them on the below-annotated graph¹¹ against the solid line representing values predicted by a model “roughly consistent” with Slonczewski’s theory. EX2037, L1036; Ross, ¶¶75-76; EX2013, 196:12-197:21. TMR increases as temperature decreases. Ross, ¶75. Saito’s circles and squares show TMR values at 250 Kelvin and 3.7K, respectively. *Id.* The 250K data is more relevant to Bowen and Nagahama who sought to make commercial devices that would function around room temperature (approximately 293K). Ross, ¶¶75, 125. Saito’s measured data did not fit the predicted values perfectly, demonstrating the limitations of theoretical models in predicting real device behavior. EX2037, L1036; Ross, ¶¶76-77. However, Saito’s predicted values and measured data ***both***

¹¹ Patent Owner added the colored lines to denote where Bowen’s alleged 0.9 eV barrier height, Soukup’s alleged 0.33 eV barrier height, and the largest barrier height value in any claim (0.85 eV) fall in the plot.

refute Petitioner's assertions that a POSA would have (1) expected Bowen's TMR to increase if its barrier height were lowered from 0.9 eV to 0.33 eV (Petition, 34) and (2) would have chosen a barrier height of 0.33 eV in Nagahama to "improve TMR" (*id.*, 57-58). Ross, ¶¶78-80.



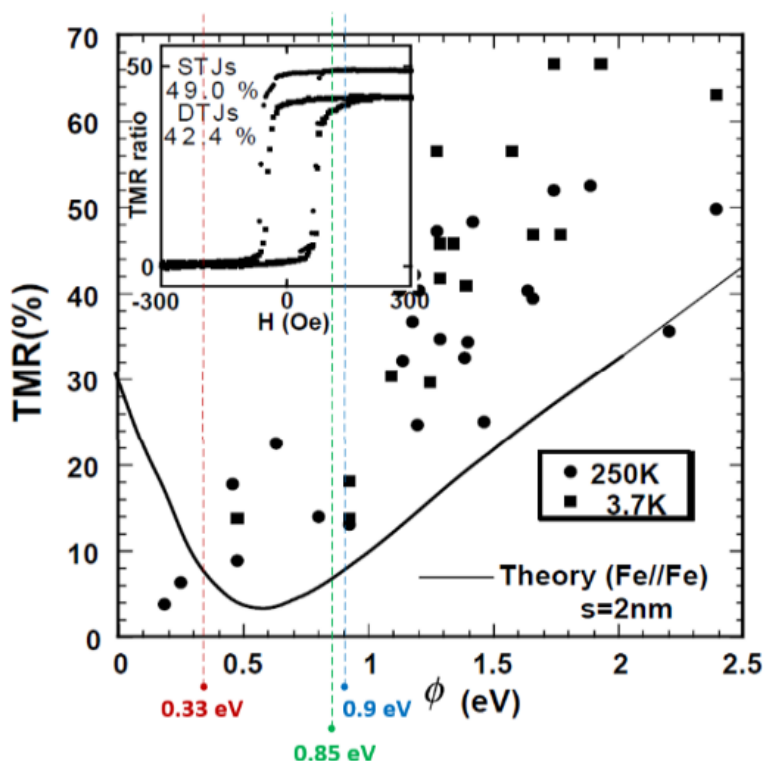
According to Saito's model and Slonczewski's theory, whether TMR would increase or decrease in response to lowering barrier height depends where on the curve one begins, i.e., what is the starting barrier height value. Ross, ¶¶78-80. But Saito concluded from the "*measured*" data that "[t]he TMR ratio increased with increasing barrier height." EX2037, L1036. As confirmed by Dr. Yuasa's peer-

reviewed article, which has been cited over **4,100** times (*supra* §IV.A), in the prestigious Nature Materials journal, POSAs believed that TMR decreased with a decrease in barrier height. EX2017, 869 (citing Saito as teaching that “for an Al-O tunnel barrier height, a lower barrier height yields a lower MR ratio” and explaining that “[i]t is surprising in Fe/MgO/Fe MTJs, there is an enormous TMR effect despite the low barrier height.”); Ross, ¶¶81-82. Moodera taught the same thing. EX1035, 3276; EX1038, 4728; Ross, ¶74.

Petitioner alleges a POSA would have lowered Bowen’s alleged barrier height of 0.9 eV to 0.33 eV (Petition, 34), and would have chosen a barrier height of 0.33 eV in Nagahama (Petition, 57-58), to increase TMR. Saito’s and Slonczewski’s models and Saito’s data teach away from that. The red (0.33 eV) and blue (0.9 eV) dotted lines in the above-annotated figure intersect the theoretical TMR curve at values that are about the same. Nothing supports Petitioner’s assertion that a POSA would have lowered Bowen’s alleged barrier height of 0.9 eV to 0.33 eV because of an expectation that it would have increased TMR. Ross, ¶¶80-82. Furthermore, a POSA would have understood from Saito’s ***data*** that the theoretically-predicted upward trend for TMR at low barrier heights would not occur in ***actual*** devices. Ross, ¶¶77, 80. That is because at low barrier heights other factors—that Saito’s and Slonczewski’s theoretical models did not account for—beyond “spin currents” from magnetized electrodes contribute to

current flow and cause TMR to decrease. Ross, ¶¶76-77. A POSA would have expected the TMR at a barrier height of 0.33 eV to be more accurately reflected by the values from Saito’s measured data. Ross, ¶80.

According to Saito’s and Slonczewski’s models and Saito’s data, a POSA seeking to increase Bowen’s TMR would have increased (not decreased) Bowen’s barrier height. Ross, ¶¶78-80. And a POSA seeking to “improve TMR” for Nagahama (Petition, 57-58) would not have chosen a barrier height of 0.33 eV because the theoretical predictions and Saito’s data show dramatically higher TMRs with larger barrier heights. Ross, ¶¶78-80.



The Board suggested that a change of Bowen’s alleged barrier height from 0.9 eV to 0.85 eV would be “slight.” DI, 18-19. As explained *infra* §V.B.6,

Petitioner offered no obviousness theory based on changing Bowen's barrier height to 0.85 eV—which would not meet over half the Challenged Claims—and only alleged a change to 0.33 eV. Additionally, according to Saito's and Slonczewski's models and Saito's data, reducing barrier height from 0.9 eV to 0.85 eV would have undesirably *decreased* TMR. Ross, ¶¶80-82; Petition, 34-36 (alleging a POSA would have modified Bowen to *increase* TMR).

Thus, the understanding in the art of a “strong influence of tunnel barrier height on $\Delta R/R$ [TMR]” (DI, 17-18) was that lowering the barrier height would have the opposite effect of what the Petition alleges—the expectation was that it would decrease rather than increase TMR. Ross, ¶¶74-76, 79-82. That refutes the only motivation Petitioner alleges for lowering the barrier height in Bowen and Nagahama which was to increase TMR. Petition, 34-36 and 57-59.

At deposition, Petitioner's expert suggested a POSA would not have expected the known relationship between barrier height and TMR in AlO MTJs to be applicable to MgO barrier layers like Bowen's and Nagahama's. EX2013, 193:5-203:24, 204:3-208:19. But Dr. Bokor admitted he was not working in the field in 2004 and has never made an MTJ device. EX2013, 32:1-36:21.

Dr. Bokor's assertion now—two decades after Dr. Yuasa's invention—that a POSA in 2004 would not have expected the known relationship that TMR decreases with a decrease in barrier height to apply to MgO devices is belied by the

contemporaneous teachings in Dr. Yuasa’s peer-reviewed widely-cited paper in the esteemed Nature Materials journal that the expectation in 2004 was that lowering the barrier height in MgO devices would have decreased TMR and that the high TMR he achieved was unexpected and surprising. EX2017, 869; Ross, ¶¶79-82.

6. Petitioner Offered No Other Valid Obviousness Theory

Petitioner’s assertion that “[t]he claimed tunnel barrier height range of 0.1 to 0.85 eV *also* would have been obvious” (Petition, 35) is legal error. The “claimed invention as a whole” must be proven obvious—not an individual claim limitation. 35 U.S.C. §103.

Petitioner alleges the claimed 0.1-0.85 eV range “is only slightly below” Bowen’s alleged barrier height of 0.9 eV. Petition, 35. Petitioner makes no similar assertion for the claimed 0.2-0.5 eV range so that assertion does not help Petitioner with over half the Challenged Claims. *See* claims 6, 12 and 15-20. Moreover, Petitioner’s assertion does not establish obviousness of *any* claim. Petitioner cites no authority supporting an assertion that a “slight[.]” difference between a claimed parameter and the prior art renders the claim obvious and obviates the need for

Petitioner to establish some *reason why*¹² a POSA would have modified the prior art to meet the claim. That is *not* the law. *In re Patel*, 566 F. App'x 1005, 1009-10 (Fed. Cir. 2014) (“Where differences clearly exist [between the prior art and the claims] and there is no evidence that they are either not meaningful or one of skill in the art would know to discard the limits set by the prior art, *proximity alone is not enough* to establish a prima facie case of obviousness.”).

Petitioner concedes that neither Bowen nor Nagahama discloses a barrier height within any claimed range (Petition, 33-34 and 57-58) so “differences clearly exist.” Petitioner provides no evidence that a difference between 0.9 and 0.85 was not meaningful, nor that a POSA would have known to “discard the limits set by the prior art.” Indeed, every prior art MgO-based MTJ of record had a barrier height at or above 0.90 eV. Ross, ¶¶46-49, 146-147; *supra* §II.F.

At institution, the Board suggested on the “[then-]current record” that lowering Bowen’s barrier height to within the claimed range of 0.1-0.85 eV “may not be as substantial as Patent Owner appears to suggest.” DI, 19 (*citing Titanium*

¹² Indeed, Petitioner concludes its paragraph alleging that a barrier height of 0.1-0.85 eV “also would have been obvious” by repeating Petitioner’s unsupported assertion that a POSA would have lowered the barrier height to “improve TMR.” Petition, 35-36.

Metals). But Petitioner never alleges that a POSA had any reason to change Bowen's barrier height to 0.85 eV. Petitioner alleges **only** that a POSA had reason to lower Bowen's barrier height to Soukup's alleged barrier height of 0.33 eV to improve TMR and Petitioner relies on this same showing to purportedly meet the smaller claimed range of 0.2-0.5 eV. Petition, 33-37 and 57-59

Petitioner never argued that a case like *Titanium Metals* (cited DI, 19) was the basis for its obviousness theory. If Petitioner belatedly advances such an argument in Reply it should not be considered. If advanced and considered, any such argument would fail because *Titanium Metals* is inapposite and Petitioner did not make the evidentiary showing necessary to support its applicability. The Federal Circuit in *Patel* distinguished *Titanium Metals* because it presented a case “much like the range cases where ***the claimed amount falls directly within the established prior art range***” whereas in *Patel*, “the claimed range unquestionably falls outside the range disclosed by the prior art.” *Patel*, 566 F. App'x at 1009-10. As in *Patel*, the claimed ranges here “unquestionably fall[] outside the range disclosed by the prior art.”

Additionally, Petitioner never alleges a POSA would have expected that if Bowen's MgO device had its barrier height lowered to 0.85 it would “have the same properties” as Bowen's unmodified device. DI, 19 (quoting *Titanium Metals*). Neither the Petition nor Dr. Bokor attempted to quantify what the TMR

would be if Bowen's device were modified to lower its barrier height to 0.85 eV (or 0.33 eV) and Petitioner's expert admitted he did not know. EX2013, 46:12-51:2, 79:15-80:24; *supra* §V.B.3. Petitioner also never addresses the impact lowering Bowen's barrier height would have had on its *RA* (*supra* §II.E). An MTJ's resistance increases as an ***exponential*** function of barrier height and thickness. Ross, ¶148. At Bowen's 2 nm barrier thickness (EX1026, 1656), reducing the barrier height from Bowen's alleged 0.9 eV value to 0.85 eV would have changed *RA* by 68%. *Id.* A POSA would have considered that *RA* change to be substantial and would not have considered the modified Bowen device to "have the same properties" as Bowen's unmodified device. DI, 19 (quoting *Titanium Metals*); Ross, ¶148.

As a matter of law, to demonstrate obviousness, Petitioner needed to establish some reason why a POSA would have modified the barrier height in Bowen and Nagahama, based on Soukup, to meet the Challenged Claims. *See supra* §V.A. Alleging that Bowen's alleged barrier height of 0.9 eV is only "slightly" above the claimed range of 0.85 eV (Petition, 35) it is legally insufficient for claims 5, 9-11 and 13-14 that recite the broader range, and ignores over half the Challenged Claims (claims 6, 12 and 15-20) where the upper end of the range is 0.5 eV.

7. Conclusion on the Petitioner's Arguments

The *only* reason Petitioner offered for why a POSA would have modified Bowen or Nagahama to meet any Challenged Claim is that a POSA would have modified them to use Soukup's alleged barrier height of 0.33 eV to lower the barrier height and thereby increase TMR. Petition, 33-36 and 57-59. The prior art taught away from this. *Supra* §V.B.5.

Even if the Board does not find a teaching away, Petitioner's expert unambiguously admitted he cited *no evidence* establishing that a POSA would have expected that lowering Bowen's or Nagahama's barrier height would have increased TMR, and that a POSA would not have known what impact lowering the barrier height would have had on TMR. *Supra* §§V.B.3-V.B.4. Both grounds fail because the only argument advanced for why a POSA would have made the combinations in Grounds 1-2 is unsupported by any evidence.

C. Dr. Bokor Offered a Different Obviousness Theory at Deposition that Should Not be Considered and Fails if Considered

At deposition, Dr. Bokor offered a new theory of why a POSA allegedly would have been motivated by Soukup to lower the barrier height of Bowen and Nagahama. This theory should not be considered and fails if it is.

1. Dr. Bokor's New Theory Cannot Be Considered

The Petition cannot incorporate arguments by reference from Dr. Bokor's declaration or anywhere else. 37 C.F.R. § 42.6(a)(3). The Petition certainly cannot

incorporate new arguments Dr. Bokor advanced at deposition. Establishing a reason to combine the references is required to establish *prima facie* obviousness and needed to be in the Petition. Dr. Bokor's new theory cannot be considered.

2. Dr. Bokor's New Theory Fails if Considered

At deposition, Dr. Bokor initially alleged that, based on Butler's theory of how MgO barrier layers would operate, a POSA would have thought that changing the barrier height *might* have some *unknown* impact on TMR, and given the limited number of options (TMR could go up, down, or stay the same), it would have been obvious for a POSA to try Soukup's alleged lower barrier height of 0.33 eV in Bowen and Nagahama and hope that it *might* increase TMR even though it was at least as likely that it would decrease TMR. EX2013, 50:9-51:22, 53:14-58:16, 79:15-80:24, 129:11-130:3, 153:5-154:19; EX2014, 38:8-40:15, 45:20-46:21. This extraordinary theory fails to establish obviousness as a matter of fact and law.

In trying to defend the Petition's assertion that a POSA would have expected TMR to *increase* if barrier height were lowered, Dr. Bokor alleged a POSA would have thought the well-known teachings in the art that lowering barrier height

would *decrease* TMR were inapplicable to MgO devices.¹³ EX2013, 193:5-203:24, 204:3-208:19. Desperately seeking to find some teaching in the art that might support the Petition’s theory, Dr. Bokor pointed to Butler. EX2013, 58:17-70:11, 73:1-74:8; EX2014, 43:9-53:14. But Dr. Bokor had to concede that Butler never says barrier height would have *any* impact on TMR. EX2013, 71:22-72:7; Ross, ¶¶85, 94, 97.

Despite testifying that Butler’s theory was extremely “complicated” and a POSA would not have been able to determine from Butler how changing barrier might impact TMR (EX2013, 64:9-21, 72:8-25, 123:5-23; EX2014, 37:2-24), Dr. Bokor initially alleged that a POSA would have read into Butler something he admits Butler does not say “explicitly” and that no publication has ever attributed to Butler. EX2013, 71:22-72:7; EX2014, 41:16-25, 42:5-23. Ross, ¶¶84-85, 94-97. Specifically, Dr. Bokor alleged that Butler suggested that barrier height *might* have *some* impact on TMR in an MgO barrier layer despite conceding that neither Dr. Bokor nor a POSA could have determined *what that impact would be*. EX2013, 64:9-21, 72:8-25, 123:5-23. Eventually, Dr. Bokor gave up trying to defend the indefensible—that Butler implicitly suggests an impact of barrier height on TMR

¹³ This is refuted by Dr. Yuasa’s 2004 peer-reviewed Nature Materials article.

Supra §V.B.5.

without suggesting what that impact would be—and admitted a POSA might believe from Butler that barrier height would have no impact on TMR at all. EX2014, 38:8-40:15, 214:18-216:19. Where Dr. Bokor was uncertain, Dr. Ross is unequivocal that Butler says **nothing** about barrier height impacting TMR and that a POSA would have drawn no conclusion from Butler about whether or how barrier height might impact TMR in an MgO barrier layer. Ross, ¶¶85, 92-97, 102.

Petitioner is limited by statute to proving unpatentability based on patents and printed publications. 35 U.S.C. § 311(b). The conclusory assertion that Butler should be read as saying something Dr. Bokor admits Butler does not say “explicitly” and that no publication has ever characterized Butler as saying—despite Butler having been cited almost **three thousand times** (EX2056)—warrants no weight. 37 C.F.R. § 42.65(a); *Xerox Corp. v. Bytemark, Inc.*, IPR2022-00624, Paper 9 at 15 (Aug. 24, 2022) (precedential); Ross, ¶¶83-102.

To the extent Dr. Bokor suggests it would have been routine experimentation to try Soukup’s allegedly low barrier height because it **might** have increased TMR, that is plainly wrong. Ross, ¶¶146-147. Dr. Bokor improperly ignores teachings in the art that taught away from lowering barrier height given the expectation that it would have undesirably **decreased** TMR. *Supra* §V.B.5. Moreover, Dr. Bokor admits there was no known relationship between barrier height and TMR in MgO devices and that a POSA would have expected it was just

as likely that lowering the barrier height might decrease or not impact TMR.

EX2013, 53:14-58:16; 79:15-80:24, 129:11-130:3, 153:5-154:19; EX2014, 38:8-39:1, 212:17-216:19.

Dr. Bokor's new theory also hinges on Soukup's erroneous alleged barrier height value of 0.33 eV and fails, like the Petition's argument does, for the reasons discussed in §§VI-IX below.

VI. BOTH GROUNDS FAIL BECAUSE PETITIONER FAILS TO ESTABLISH THAT SOUKUP IS ANALOGOUS ART

“A reference qualifies as prior art for an obviousness determination...*only when it is analogous to the claimed invention.*” *In re Klein*, 647 F.3d 1343, 1348 (Fed. Cir. 2011). Petitioner bears the burden to prove Soukup analogous. *Sanofi-Aventis v. Mylan Pharms.*, 66 F.4th 1373, 1377 (Fed. Cir. 2023). Petitioner must demonstrate that Soukup is either (1) from the same field of endeavor as the '909 Patent or (2) reasonably pertinent to the particular problem with which the inventor was involved. *In re Bigio*, 381 F.3d 1320, 1325 (Fed. Cir. 2004). Petitioner did neither.

A. Soukup Is Not In the Same Field of Endeavor As the '909 Patent

To ascertain the field of endeavor, the Federal Circuit has looked to the patent's title, claims, Abstract, Background of the Invention, Field of the Invention, and the function and structure of the claimed invention. *Airbus v. Firepass*, 941 F.3d 1374, 1380, 1381 n.8 (Fed. Cir. 2019) (determining field from

title, claim preamble and field of the invention); *Kamstrup v. Axioma*, 43 F.4th 1374, 1384 (Fed. Cir. 2022) (discerning field from the abstract); *In re Bigio*, 381 F.3d 1320, 1326 (Fed. Cir. 2004) (“The Board...correctly set the field...by consulting the structure and function of the claimed invention”); *In re Wood*, 599 F.2d 1032, 1036 (CCPA 1979) (field from “Background of Invention”).

1. The '909 Patent's Field of Endeavor is MTJ Devices

The '909 Patent's Title recites a “magnetoresistive” device and the “Field of the Invention” says “The present invention relates to [] *a magnetic tunnel junction device with a high magnetoresistance*.” EX1017, 1:33-2:41.

The “Description of Related Art” discusses a “*magnetic tunnel junction device*” in FIGS. 8(A)-8(B) having parallel and antiparallel states. *Id.*, 1:51-2:40.

The Abstract describes an “Fe(001)/MgO(001)/Fe(001) *MTJ device*.” EX1017, Abstract (57).

Every claim recites a “magnetic tunnel junction structure” or a “tunnel barrier” between ferromagnetic layers. *Id.*, 9:65-11:5 (claims); EX1024, ¶85 (Petitioner's expert agreeing the “'909 Patent's claims are directed to an *MTJ device*.”)

All the sources the Federal Circuit uses to identify a patent's field of endeavor make clear that the '909 Patent's field is magnetoresistive devices and more specifically MTJ devices. Ross, ¶¶113-117.

2. Soukup's Field of Endeavor is Electrical Conductance Through MgO Films

Soukup is titled "Voltage-Current Characteristics for Electrical Conductance Through Thin MgO Films." Soukup, 3229. Soukup fabricated 60 thin-film "*Au-MgO-Au emission diodes*" and measured *I-V* characteristics of 13 of them. Soukup, 3229-3230. Soukup is not in the same field as the '909 Patent for two reasons.

First, gold is not magnetic. EX1027, [0011]-[0012] ("nonmagnetic" gold), [0043]; Ross, ¶¶118-119. Soukup's devices are not magnetoresistive devices, let alone MTJs. Indeed, Soukup was published in 1970 before Julliere discovered the TMR effect in 1975. EX1033 (Julliere); EX2010, 172; EX1057 (Dieny 2017), 42; Ross, ¶121; EX2014, 219:24-220:11.

Second, the current-flow mechanism of importance in an MTJ is tunneling and Soukup determined that the electron process of importance in his devices that Petitioner relies on was *not* tunnelling. Ross, ¶120. Soukup concluded that the "voltage-current characteristics of *Au-MgO-Au thin-film emission diodes* ... are consistent with an expression derived for *Schottky field emission*." Soukup, 3229 (Abstract). The Board preliminarily stated that Soukup reached no definite conclusion. DI, 21-22. But Soukup did definitively "rule out" tunneling (*see infra* §§VII.A-VII.B) and both experts agree Soukup concluded that the dominant

current-flow mechanism was Schottky emission. Ross, ¶¶104-106, 110, 120; EX2013, 185:11-17; 2014, 221:19-223:8.

Soukup's study of *non-magnetic* devices in which the dominant current-flow mechanism is *not tunneling* is not in the same field (*magnetic tunnel* junction devices) as the '909 Patent. Ross, ¶¶118-121.

B. Soukup is Not Reasonably Pertinent to the Particular Problem with Which the '909 Patent is Involved

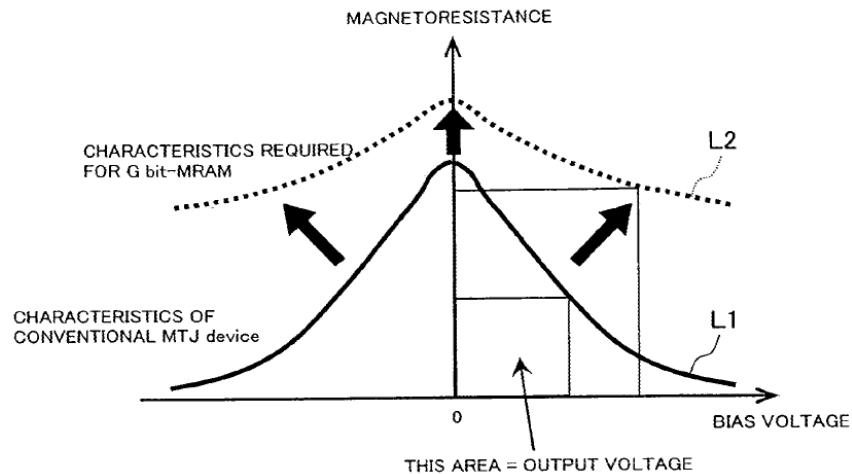
1. Dr. Yuasa Sought an MTJ Device with Improved TMR and Output Voltage

The problem the inventor sought to solve was improving “the characteristics of the MTJ device” to support MRAMs with greater capacities than the 64 Mbits achievable with then-current technologies. EX1017, 2:45-49; Ross, ¶122.

Dr. Yuasa sought to increase TMR (which he called magnetoresistance) and output voltage (impacted by the MTJ's resistance) because both were small in conventional devices which resulted in “signals [that] are increasingly lost in noise and cannot be read.” *Id.*, 2:49-67; Ross, ¶¶123-124. As shown by solid-line L1 in Fig. 10 (below), conventional MTJs had a “small” TMR (labelled “magnetoresistance”) of approximately 70% that “drastically decrease[d] upon application of bias voltage.” *Id.*, 2:52-58. Conventional MTJs also had small output voltages of 200 mV. *Id.*, 2:61-65. Dr. Yuasa recognized that MTJ devices with

those characteristics would not support higher-capacity MRAMs. *Id.*, 2:59-61; Ross, ¶¶123-124.

FIG. 10



Dr. Yuasa explained that “Julliere’s formula predicts a highest estimated MR ratio of about 70%.” *Id.*, 5:8-38. He noted that although this approximately 70% TMR had been obtained with “an amorphous Al-O tunnel barrier and polycrystalline electrodes, it has been difficult to obtain the output voltage of 200 mV ... thereby preventing the realization of MRAM.” *Id.*, 5:8-38; *see also* 2:62-68; Ross, ¶124.

Thus, the problem Dr. Yuasa sought to solve was achieving an MTJ device with a high TMR, with less bias voltage decay, and a high enough output voltage suitable for use in larger MRAMs. EX1017, 2:45-4:8; Ross, ¶125.

Dr. Yuasa solved this problem. His Fe(001)/MgO(001)/Fe(001) MTJ embodiment achieved a TMR of 88% at room temperature (293 K) which was the highest TMR “ratios so far obtained at room temperature.” EX1017, 8:15-21, FIG. 7(A); Ross, ¶125 (TMR is temperature dependent and commercial applications operate at room temperature). This high TMR was thought to be achieved because of “coherent spin-polarized tunneling” (EX1017, 8:21-24) due to compatibility of the crystalline structures¹⁴ of the Fe electrodes and the MgO layer. Ross, ¶¶41-43, 126; *supra* §III.B. The TMR desirably had fairly small “bias voltage dependency” at room temperature. EX1017, 8:15-21; Ross, ¶127. And the output voltage of 380 mV was “about twice as large” as that from conventional Al-O barriers. EX1017, 8:41-45, FIG. 7(B); Ross, ¶127. “These high values in terms of both [T]MR ratio and output voltage suggest the effectiveness of the technique according to the present embodiment.” EX1017, 8:44-46.

2. Soukup’s Study of Emission Diodes With No TMR Was Not Reasonably Pertinent to the Problem Dr. Yuasa Solved

First, because Soukup’s devices were not magnetic they had no TMR. Soukup, 3229; Ross, ¶128. Soukup was not reasonably pertinent to Dr. Yuasa’s problem of producing a device with a high TMR. Ross, ¶128.

¹⁴ Claims 5, 10-11, 13 and 16-18 recite a crystalline structure for the MgO and/or electrode layers.

Second, it is undisputed that the dominant current flow mechanism in Soukup’s devices was not tunneling. EX1028, 3231, 3225-3236; Ross, ¶¶104-106, 110, 120, 129; EX2013, 185:11-17; 2014, 221:19-223:8, 224:22-225:5; *infra* §VII.B.

Nothing in Soukup’s analysis of non-magnetic devices with no TMR, and for which the dominant current flow mechanism was not tunneling, was reasonably pertinent to the problem Dr. Yuasa was involved with, i.e., achieving a ***magnetic tunnel*** junction device with improved ***TMR*** and output voltage. Ross, ¶¶128-131; EX2014, 219:24-223:8; *supra* §VI.B.1.

C. No MTJ Researchers Considered Soukup Relevant

Soukup has been cited just 17 times in the 55 years since its publication and never by a reference describing MTJ devices. EX2057. Neither Bowen, Nagahama nor any other reference Petitioner cited—including a textbook covering the basics of tunneling and spintronics (EX1057) and papers studying MgO layers in MTJs¹⁵—mentions Soukup. Dr. Bokor admitted he could not recall being aware of Soukup before becoming involved in this case. EX2013, 190:6-22. No practitioners working in the ’909 Patent’s field of endeavor considered Soukup relevant.

D. Conclusion

¹⁵ See e.g., EX1036-EX1047; EX1051-EX1053; EX1058.

Petitioner could not find an MTJ device with an MgO barrier layer and a tunnel barrier height within either claimed range. Petitioner searched for an alleged “barrier height” within the claimed ranges and found Soukup—a 1970 study of *non-magnetic* emission diodes *pre-dating discovery of the TMR effect*—then alleged Soukup would have somehow motivated a POSA to modify a *magnetic tunnel* junction device to *improve its TMR*. The non-analogous art exclusion prevents precisely this type of hindsight attack. Petitioner cannot carry its burden to demonstrate that Soukup is analogous prior art to the ‘909 Patent. That is fatal to both Grounds 1-2. *In re Klein*, 647 F.3d at 1348.

VII. SOUKUP WOULD NOT HAVE MOTIVATED A POSA TO MODIFY THE BARRIER HEIGHT OF BOWEN’S OR NAGAHAMA’S MTJ DEVICE TO BE 0.33EV

Even if the Board were to find Soukup to be within the pool of prior art a POSA would have considered, Soukup would not have motivated a POSA to modify Bowen’s or Nagahama’s MTJ device in the manner Petitioner alleges.

A. Soukup’s Study

Soukup studied the current-flow mechanism in “metal-insulator-metal sandwich devices” because in 1970 “the electron processes of importance in these devices [were] in some doubt.” Soukup, 3229. Soukup studied 13 thin-film Au-MgO-Au devices “in detail” by measuring their electron emissions at different voltages and temperatures to obtain *I-V* (current-voltage) characteristics. Soukup,

3230. Soukup compared the I - V characteristics to models for different known current-flow mechanisms and ruled out those whose models the I - V characteristics did not fit. Soukup, 3230-3233; Ross, ¶103

Soukup first “ruled out” tunneling as the electron process of importance for 12 of his 13 devices (*Id.*, 3230, 3235) because the I - V characteristics “did not plot as a straight line on a $\ln(I/V^2)$ vs I/V plot” as would have been expected if tunneling was of significance (*Id.*, 3230). Ross, ¶¶104-105. The only device for which Soukup did not rule out tunneling as the dominant current-flow mechanism was the device for which Soukup calculated barrier heights of 1.9 eV and 1.74 eV. Soukup, 3232-3233; Table I (PY-G-38(1)). Like all of Soukup’s other “barrier height” values, these were not tunnel barrier heights calculated using Simmons’ formula as required by the ’909 Patent. EX1017, 7:38-8:14. If any of Soukup’s alleged “barrier height” values have any relevance, Petitioner ignores the values for the only device for which tunneling was not ruled out because the values are well outside either claimed range. Soukup, 3232-3233 (Table I); Ross, ¶105.

For the 12 devices for which tunneling was “ruled out,” Soukup found the measured I - V characteristics consistent with Schottky field emission because the I vs $V^{1/2}$ plots were linear as predicted by van der Ziel’s equation. Soukup, 3230, 3232, 3235-3256; Ross, ¶106. After ruling out another current-flow mechanism (“Poole-Frankel effect”), Soukup computed “barrier heights” – based on his

determination that Schottky emission was the current flow mechanism of importance – by fitting the I - V curves to the Richardson-Schottky equation (not Simmons’ formula) and using the zero-field intercept method which yielded values from 0.694-0.823 eV. Soukup, 3231, Table I; Ross, ¶¶106; EX2013, 161:15-162:14, 162:23-166:10. Soukup also calculated “barrier heights” using an Arrhenius plot (not Simmons’ formula)—which measures temperature-dependence of the I - V curves—and obtained different “barrier height” values including the 0.33 eV value Petitioner relies on. Soukup, 3232; Ross, ¶¶107-109; EX2013, 166:11-169:25.

Soukup’s two measurement techniques not only yielded different results for the alleged “barrier heights,” they yielded contradictory results in terms of whether added oxygen increased or decreased alleged barrier height. Soukup, 3229 (Abstract), 3232. Petitioner’s expert admitted Soukup did not know which results were correct and a POSA would not have known. EX2013, 173:15-174:4, 174:5-176:1, 176:6-180:16, 180:17-185:10. Dr. Ross explains that a POSA would have known the Arrhenius plot “barrier height” values—including 0.33 eV—were too low for what Soukup was trying to determine and would not have known if the zero-field intercept values were accurate. Ross, ¶¶107-110, 141.

B. Soukup Would Not Have Motivated a POSA to Lower the Barrier Height in Bowen’s or Nagahama’s MTJ to increase TMR Because Soukup’s Devices Lacked TMR and Their Dominant Current-Flow Mechanism was Not Tunneling

Soukup hypothesized that introducing oxygen into the vacuum chamber would increase something Soukup called barrier height, but Soukup never says a higher or lower “barrier height” was preferred. Ross, ¶¶133. Soukup just tested the alleged barrier height of devices made with different oxygen pressures during MgO deposition and got conflicting results. Ross, ¶¶111, 113.

As explained *supra* §V.B, the sole reason why Petitioner alleges a POSA would have “explore[d] [Soukup’s] lower barrier heights” was to “increase TMR.” Petition, 35-36 and 57-58. But given that Soukup tested *non-magnetic* devices without a TMR (*supra* §VII.A), Soukup would not have motivated a POSA to lower the barrier height of Bowen’s or Nagahama’s MTJ’s *to increase TMR*. Ross, ¶¶80-82, 134-140; EX2014, 219:3-220:11, 221:19-223:8.

Petitioner alleges “Bowen[, Nagahama] and Soukup studied properties of MgO barriers and *were focused on improving tunneling devices*, the problem to which the ’909 Patent was directed.” Petition, 35 and 58. Dr. Bokor did not support the naked attorney argument that *Soukup* was “focused on improving tunneling devices” because that is manifestly untrue. Ross, ¶¶133. Dr. Bokor only said Soukup “*discussed tunneling*.” EX1024, ¶171. But Soukup only “discussed tunneling” as a *potential* current-flow mechanism of importance that was *ruled out*. Ross, ¶¶104-106, 133.

At institution, the Board noted Soukup’s statement that he reached no “definite conclusion” as to the “current flow mechanism [] in its tested devices.” DI, 21. What Soukup reached “no *definite* conclusions” about was whether Schottky emission was the dominant current-flow mechanism. Soukup, 3236; Ross, ¶¶105-106, 110, 120. That’s because the temperature dependence of the I - V curves using the Arrhenius plot method were not entirely consistent with Schottky emissions.¹⁶ Soukup, 3232, 3236; Ross, ¶¶107-110. That Soukup reached no “definite conclusion[]” (DI, 21) that Schottky emission *was* the dominant current-flow mechanism does not change that he reached a definite conclusion that tunneling *was not*. It is undisputed that Soukup “ruled out” tunneling for every device except the single device with alleged “barrier heights (1.9 and 1.74 eV) well outside either claimed range. Soukup, 3232-3233, Table I (see device PY-G-38(1)); Ross, ¶¶105-110; EX2013, 185:11-17; EX2014, 219:24-220:11, 221:19-223:8, 224:22-225:5.

In short, it is undisputed that Soukup’s devices are not magnetic, have no TMR, and that the dominant current-flow mechanism in the devices with alleged “barrier heights” within either claimed range is not tunnelling. EX2013, 135:11-

¹⁶ Soukup’s author provided greater detail in his doctoral thesis where he explained that the Arrhenius plot values were too low. EX2039, 88-89; Ross, ¶¶107-109.

136:11, 185:11-17; EX2014, 219:24-223:8, 224:22-225:5; Ross, ¶¶105-110, 120, 128-131. Thus, Soukup would not have motivated a POSA to lower the barrier height of Bowen's or Nagahama's *magnetic tunnel* junction device *to increase TMR* as Petitioner erroneously alleges. Petition, 33-36 and 57-59; Ross, ¶¶78-82, 132-133. Both grounds fail for that additional reason.

C. A POSA Would Not Have Lowered Bowen's or Nagahama's Barrier Height to a Value Where Soukup Teaches Schottky Emissions Dominate Because that Would Decrease TMR

At deposition, Petitioner's expert alleged a POSA would have been motivated to use Soukup's alleged "barrier height" of 0.33 eV in Bowen's and Nagahama's MTJs because it is a low number and while a POSA would not have known if adopting that "barrier height" would have increased, decreased or had no impact on TMR, a POSA would have tried a barrier height of 0.33 eV to see if it increased TMR. EX2013, 180:17-183:7, 129:18-130:3, 154:1-19. This assertion is wrong for many reasons.

First, a POSA would not have trusted Soukup's 0.33 eV value and would have known that real value for what Soukup was trying to determine was higher. *Infra* §VII.D.

Second, given that it is undisputed that a POSA would have not expected TMR to increase in response to lowering barrier height to 0.33 eV (*supra* §V.B.5), Dr. Bokor's assertion is based on nothing but improper hindsight.

Third, if a POSA believed that Soukup’s devices had a barrier height within the claimed range and that Soukup’s teachings had any relevance to TMR in an MTJ device, then a POSA would have avoided the modification Petitioner alleges because Soukup teaches that at any alleged “barrier height” within the claimed range the dominant current-flow mechanism was *not* tunneling and POSAs understood that increasing non-tunneling forms of current flow would have *decreased* TMR. Ross, ¶¶134-140.

More specifically, for devices with alleged “barrier height” values within either claimed range, Soukup found that the current-flow process of importance was *not tunneling* and was most likely Schottky field emission. *Supra* §§VII.A-VII.B; Soukup, 3231-3233, 3235; Ross, ¶¶105-110. Tunneling and Schottky emissions are different current-flow mechanisms. EX2014, 221:19-223:8; Ross, ¶¶135-138. Tunneling is a quantum effect in which electrons tunnel through the insulator despite having *insufficient energy to surmount* the insulator’s energy barrier. Soukup, 3229; EX1031, 1794; Ross, ¶135. In Schottky emissions, electrons have sufficient energy to surmount the insulator’s energy barrier. Soukup, 3220; EX1031, 1794; Ross, ¶¶137-138.

POSAs understood that lowering the barrier height to where the dominant current-flow mechanism is Schottky emissions—or *any* mechanism other than spin-dependent tunneling—would *decrease* TMR. Ross, ¶¶134-136. That is

because TMR results from magnetic-state-dependent tunneling (i.e., the quantum mechanical effect of spin-dependent tunneling). *Supra* §§II.B-II.D; Ross, ¶¶35-43, 135. Thermionic emissions like Schottky emissions are not intrinsically spin-dependent so lowering the barrier height to where thermionic emissions become the dominant current-flow mechanism would reduce the percentage of current flow that is magnetic-state-dependent and thus decrease TMR. Ross, ¶¶136-138 (citing EX1057, 19; EX2037, L1037) (showing how TMR decreases via magnetic-state-independent conductance using the TMR equation). This is similar to the effect Saito saw (discussed *supra* §V.B.5) where at low barrier heights the measured TMR was less than predicted by spin-dependent tunneling models. Ross, ¶138.

Both experts agree a POSA would have avoided barrier heights in an MTJ that were so low that a significant percentage of the current flowing through the MTJ was from non-tunnelling thermionic emissions (like Schottky emissions) because that would decrease TMR. Ross, ¶¶136-139; EX2013, 86:21-88:15. And both experts agree that for the Soukup devices with alleged barrier heights (including 0.33 eV) within the claimed ranges, the “*dominant* current mechanism in these devices was Schottky emission.” EX2013, 185:11-17; Ross, ¶¶105-106, 110, 120;

Thus, if a POSA considered Soukup relevant, a POSA would not have lowered the barrier height in Bowen’s or Nagahama’s MTJ to be within either

claimed range because Soukup teaches that at those alleged barrier heights current flow is dominated by Schottky emissions which would have *decreased* TMR.

Ross, ¶140.

The prevailing view in the art was that reducing the barrier height of Bowen or Nagahama would have decreased (not increased) TMR. *Supra* §V.B.5 (discussing Saito). Dr. Bokor’s assertion that a POSA would not have predicted the same relationship for MgO devices (EX2013, 193:5-203:24, 204:3-208:19) is refuted by Dr. Yuasa’s contemporaneous Nature Materials article. *Supra* §V.B.5. Moreover, to the extent it has any relevance, the *only* MgO reference Petitioner cites with an alleged “barrier height” value within either claimed range—Soukup—teaches that a “barrier height” within the claimed range would have resulted in non-tunnelling current dominating which a POSA would have expected to decrease TMR. Ross, ¶¶134-140. Thus, *all* the evidence taught away from Petitioner’s modifications to Bowen and Nagahama and away from what Dr. Yuasa did. That is why his peer-reviewed article in the prestigious Nature Materials journal explains that his results were surprising and unexpected. *Supra* §III.B.

Petitioner’s assertion that a POSA would have expected that adopting a barrier height of 0.33 eV in Bowen or Nagahama would have *increased* TMR (Petition, 33-36 and 57-59) is not only *unsupported* by any evidence—it is *refuted*

by all the evidence which demonstrates that a POSA would have expected exactly the opposite to have occurred and that TMR would have decreased. Ross, ¶¶78-82, 134-140. Grounds 1-2 fail for that additional reason.

D. Petitioner Improperly Cherry-Picks From Soukup’s Teachings and Relies on an Alleged Barrier Height Value a POSA Knew Was Wrong

Petitioner relies on Soukup to teach an alleged “barrier height” (0.33 eV) within both claimed ranges and that adding oxygen vacancy defects would have been expected to lower Bowen’s and Nagahama’s barrier heights. Petition, 33-36 and 57-59. There are multiple problems with these assertions.

First, Soukup’s author provided greater detail on his study in his doctoral thesis where he explained that the reported Arrhenius plot method values (including 0.33 eV) were too low. EX2039, 88-89; Ross, ¶¶107-109. If Soukup is analogous art then so too is the published thesis. A POSA is imbued with knowledge of *all* the prior art. *In re Rouffet*, 149 F.3d 1350, 1357 (Fed. Cir. 1998). 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. Ross, ¶141.

Second, Petitioner relies on an alleged relationship between oxygen vacancy defects and “barrier height” established by measurements using the zero-field intercept method. Petition, 33-36, 57-59; DI, 22. But as the Board acknowledged,

Soukup taught the “opposite relationship” for the Arrhenius plot method (DI, 22) that yielded an alleged barrier height value of 0.33 eV. EX1028, 3229, 3233 (Table I); Ross, ¶¶111, 133. Petitioner cannot have it both ways. If a POSA would have credited the alleged barrier height values Soukup calculated using the Arrhenius plot method (including 0.33 eV), then the POSA would have believed that adding oxygen vacancy defects would have increased barrier height and would not have added oxygen vacancy defects in an attempt to lower the barrier height of Bowen or Nagahama as Petitioner alleges. Petition, 33-35, 57-59; Ross, ¶141.

Conversely, if a POSA would have believed that the zero-field intercept method accurately measures the alleged barrier height and its relationship to oxygen vacancy defects, a POSA would have considered the correct “barrier height” values to be those reported using that method. Ross, ¶142. The values calculated using the zero-field intercept method fail to meet more than half the Challenged Claims (claims 6, 12 and 15-20) so Petitioner ignored them. Ross, ¶142.

If Soukup has any relevance despite the issues discussed *supra* §§VI and VII.A-VIII.C and despite Soukup’s “barrier heights” not being determined using Simmons’ formula (EX1017, 7:38-8:14), then ***all*** Soukup’s teachings must be considered. Petitioner’s hindsight picking and choosing of selective Soukup teachings fails to establish obviousness as a matter of law. *In re Fine*, 837 F.2d

1071, 1075 (Fed. Cir. 1988). (“One cannot use hindsight reconstruction to pick and choose among isolated disclosures in the prior art to deprecate the claimed invention.”).

VIII. PETITIONER’S ASSERTION THAT A POSA WOULD HAVE INJECTED OXYGEN DEFECTS INTO BOWEN’S AND NAGAHAMA’S MGO LAYER TO INCREASE TMR FAILS

Because Bowen and Nagahama sought to experimentally test theoretical predictions that MgO layers could produce high TMR—due to coherent tunneling enhancement (*supra* §II.D)—by using a *perfect defect-free crystalline MgO layer*, Bowen and Nagahama sought to make the MgO layer as defect-free as possible. EX1026, 1655 (citing Butler), 1657; EX1027, ¶14 (citing Mathon), ¶17; Ross, ¶¶47-49, 134, 143. A POSA never would have injected oxygen vacancy *defects* into Bowen or Nagahama in an attempt to increase TMR as Petitioner erroneously alleges. Petition, 33-35, 57-59. A POSA seeking to increase TMR would have done the opposite and tried to eliminate oxygen vacancy defects. Ross, ¶143.

Soukup offers no contrary teaching because Soukup’s devices lack TMR (*supra* §VII.B) and because, contrary to Petitioner’s mis-characterization, it is undisputed that Soukup did not introduce oxygen vacancy defects. *See supra* §VII.D (Soukup instead introduced oxygen to *reduce* oxygen vacancy defects). Here again, a POSA seeking to increase TMR would have done the opposite of what Petitioner alleges.

Dr. Yuasa proceeded contrary to the teachings in the art which is why his results were so surprising and unexpected and why they received so much acclaim. *Supra* §§III.B, IV.A; Ross, ¶¶57-58, 61, 155-162.

IX. PETITIONER FAILS TO ESTABLISH A REASONABLE EXPECTATION OF SUCCESS FOR EITHER GROUND

Petitioner alleges a POSA would have had a reasonable expectation of success in “achieving a tunnel barrier height in the claimed range in Bowen’s MTJ” because “*Soukup fabricated an MgO barrier that achieved a height of 0.33 eV*” and a POSA was motivated “to achieve *Soukup’s barrier height* in an MgO MTJ.” Petition, 35. Ground 2 makes the same argument – alleging a reasonable expectation of success in “achieving *Soukup’s tunnel barrier height* in Nagahama’s MTJ” because “*Soukup had already shown that an MgO barrier achieved a height of 0.33 eV*.” Petition, 58. This assertion fails for multiple reasons.

First, Petitioner’s reasonable expectation of success showing is premised on the false assertion that Soukup “already” achieved a “barrier height” of 0.33 eV. Petition, 35 and 58. A POSA would have known that Soukup’s 0.33 eV value understates the “*real* barrier height” Soukup was trying to determine. EX2039, 89. Even if Soukup’s “barrier height” were considered a tunnel barrier height, Petitioner presents no evidence of the device’s *real* barrier height. *See supra* §VII.D; Ross, ¶¶107-109, 141, 144.

Second, Petitioner alleges a POSA would have modified Bowen's and Nagahama's devices. Petition, 33-36 and 57-59. The only modification Petitioner alleges is increasing oxygen vacancy defects to lower their barrier heights to 0.33 eV. Petition, 34 and 58-59. Citations to the '909 Patent (Petition, 36 and 59) cannot save Petitioner. *Sensonics Inc. v. Aerosonic Corp.*, 81 F.3d 1566, 1570 (Fed. Cir. 1996). Neither Soukup nor any **prior art** reference supports the assertion that the tunnel barrier height of Bowen or Nagahama could be lowered to 0.33 eV by introducing oxygen vacancy defects. As discussed *supra* §VII.D, if a POSA believed Soukup's zero-field intercept method accurately measured tunnel barrier height and its relationship to oxygen vacancy defects, a POSA would have considered the correct "barrier height" values to be those reported using the zero-field intercept method which are well above the 0.33 eV value that Petitioner's reasonable expectation of success showing relies on.¹⁷ Petition, 35 and 58-59; Ross, ¶¶141-142, 144; Soukup Table I.

Additionally, tunnel barrier height is impacted by MTJ device characteristics beyond oxygen vacancy defects in the MgO layer including, *inter alia*, the material

¹⁷ Petitioner did not rely on the values Soukup calculated using the zero -field intercept method because they do not meet more than half the Challenged Claims (claims 6, 12 and 15-20).

of each ferromagnetic layer, the crystalline structure (or not) of the ferromagnetic layers, the crystalline structure (or not) of the MgO layer and how it relates to the crystalline structure of each ferromagnetic layer. Ross, ¶145. These characteristics in Bowen’s and Nagahama’s devices are different than in Soukup’s devices. Ross, ¶¶130, 144. Petitioner’s assertion that a POSA in 2004 would have reasonably expected that they could have achieved a tunnel barrier height of 0.33 eV in Bowen or Nagahama by introducing oxygen vacancy defects without undue experimentation is unsupported by any evidence and is plainly wrong. Ross, ¶¶144-147; EX2013, 90:3-99:20, 100:15-104:11; EX2014, 63:11-64:15.

Finally, Petitioner’s nonsensical assertion that Patent Owner’s infringement contentions somehow demonstrate obviousness fails. Petition, 36. Patent Owner will carry its burden to prove infringement in the litigation. Petitioner bears the burden to demonstrate obviousness here and fails to do so.

X. SOUKUP’S 0.33 EV VALUE IS NOT A TUNNEL BARRIER HEIGHT

Soukup’s 0.33 eV value is not a “tunnel barrier height” as claimed because it was not determined using Simmons’ formula as the ‘909 Patent requires to determine tunnel barrier height. EX1017, 17:38-8:14; Ross, ¶108. None of the above arguments in §§V-IX hinge on the claimed “tunnel barrier height” being determined using Simmon’s formula. If the Board agrees with any of those arguments, it can resolve the parties’ dispute—by finding that both grounds fail—

without reaching this claim construction issue. *Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017).

XI. CONCLUSION

Both grounds fail for the reasons detailed above.

Respectfully submitted,
GODO KAISHA IP BRIDGE 1

Date: July 16, 2025

/Richard Giunta/

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CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24, the undersigned certifies that the foregoing **PATENT OWNER'S RESPONSE** contains 13,996 words excluding; a table of contents, a table of authorities, a certificate of service or word count, or appendix of exhibits or claim listing. Patent Owner has relied on the word count feature of the word processing system used to create this paper in making this certification.

Date: July 16, 2025

/Dara Del Rosario/

Dara Del Rosario

Paralegal

WOLF, GREENFIELD & SACKS, P.C.

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

I certify that on July 16, 2025, a copy of the foregoing document, including any exhibits filed therewith, is being served via electronic mail, as previously consented to by Petitioner, upon the following:

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